The Quanta 200 3D
User's Operation Manual

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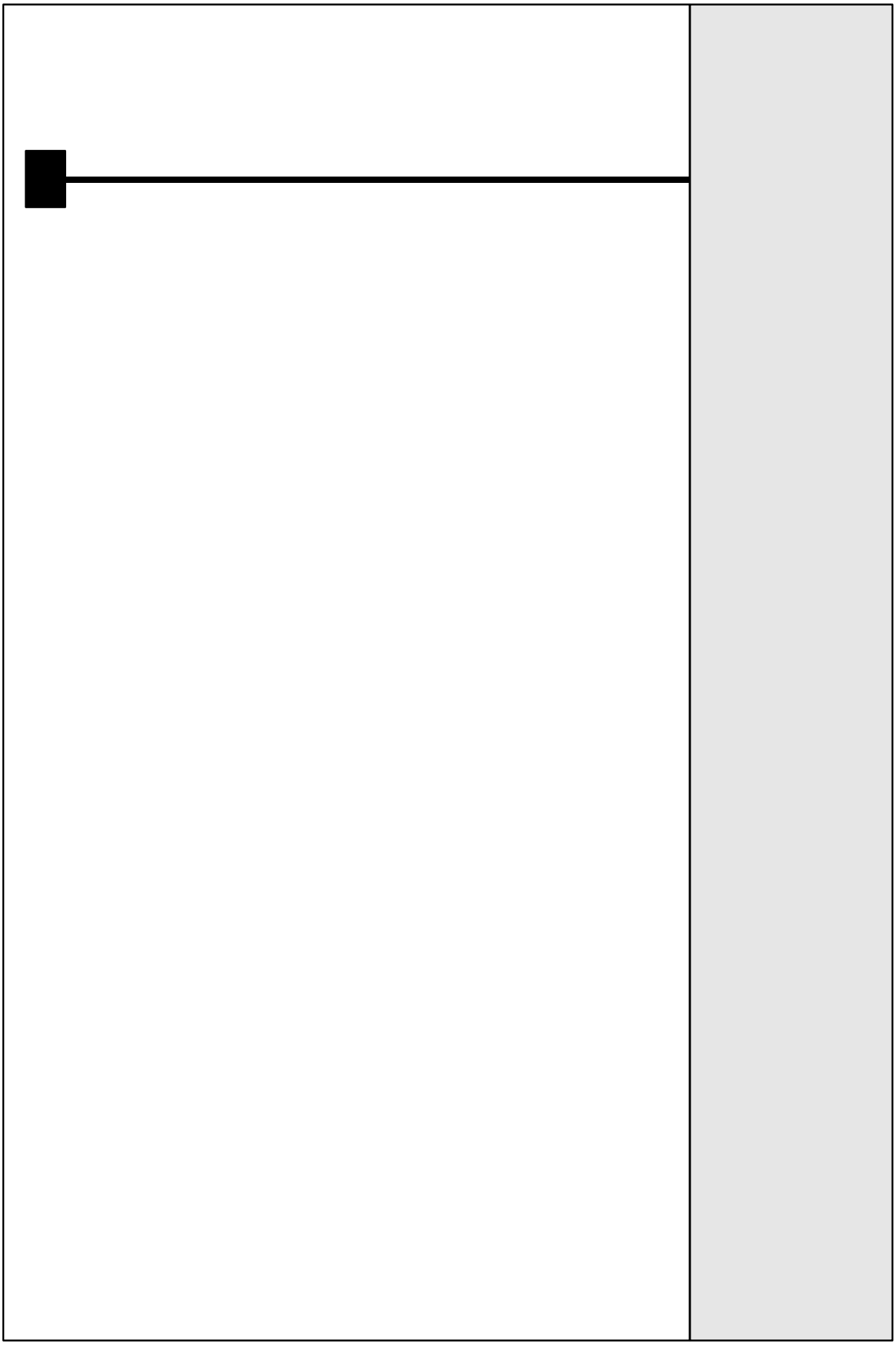

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PREFACE

Manual Structure

The manual for your Quanta 3D Scanning Electron Microscope is divided into the following chapters:

1. **SAFETY AND HANDLING**
   provides important information required during operation and maintenance for product safety and personal safety.
2. **SYSTEM OVERVIEW**
   gives the basics about your system's capabilities.
3. **VACUUM SYSTEM**
   gives the basics about the vacuum system and procedures for several system on/off modes, including Log On/Off, Standby Mode, Sleep Mode, Complete Shutdown, and Emergency Shutdown.
4. **SOFTWARE CONTROL**
   describes the interface that controls system operation, giving the function of each tool, menu item and control page.
5. **OPERATIONS**
   gives procedures for how to use the system.
6. **ALIGNMENT**
   explains how to align the column and stage to achieve optimal performance.
7. **STAGES**
   gives a full description of functionality for each stage and the software control.
8. **MAINTENANCE**
   gives step by step cleaning and maintenance procedures.
9. **SYSTEM OPTIONS**
   explains relevant options that are integrated into or accessory to the Quanta 3D system.

How to Use this Manual

This manual is available in two forms, either in the printed form or as an electronic PDF file.

You can read the manual from beginning to end (highly recommended but rarely done). Be sure to read Chapter 1 - Safety and Handling at least before operation. Most importantly, you should locate the topics necessary to operate the microscope in the proper way to safely achieve the best results.

In the electronic PDF file you can take advantage of the searching and navigation possibilities offered by this file format. In the printout the following conventions are observed to be of help:

- You can search for the information in the main table of contents at the beginning of the User's manual, where tables and figures (excluding explanatory ones) are also listed.
- Included in some chapters are easy-to-follow tables outlining task-oriented procedures.
- Major headings have been hung in the left column to help you scan for the basics within a chapter. That column provides space for some explanatory figures and for your own notes as well.
- Some software functions use shortcuts, which are given beside the heading in the brackets, for instance: **Save (Ctrl + S)**
- Pages are numbered by this way:
  [Chapter No.]-[Page No.] within the Chapter
  Instead of **[Chapter No.]** you can find these abbreviations:
  P - preface, **C** - content, **I** - index
- Tables and figures (excluding explanatory ones)
  are numbered within each chapter in this way:
  FIGURE [Chapter No.]-[Figure No. within the Chapter] (
  TABLE [Chapter No.]-[Table No. within the Chapter]
- References to specific knobs, buttons, labelled functions on the system and software are highlighted in bold to aid association of items. A sentence such as: "Click on the **Measurement** button to start this function" refers to the software button itself.

1 SAFETY AND HANDLING

Machine classification

These instruments are safe with respect to:

- **IEC61010-1** Safety requirements for electrical equipment: general requirements
- **IEC61326-1** Electrical equipment for measurement, control and laboratory use - EMC requirements
- **EN50081** EMC Generic emission standard
- **EN50082** EMC Generic immunity standard
- **96/29/EURATOM** Ionizing radiation
- **CE**
- **Low voltage directive**
- **EN61010-1**
- **EMC directive**
- **Euratom directive**

Note:
EMC - Electro Magnetic Compatibility

These instruments are classified as:

- **Plug connected**
- **Safety class 1** (EN61010-1)
- **Installation (Overvoltage) category 2** (EN61010-1)
- **Pollution class 2** (EN61010-1)
- with a second, hardwired, earth connection to the building ground

All electron beam instruments generate some ionizing radiation (X-rays). The level of this is less than 1 µSv/h at a distance of 10 cm from the surface.

For Quanta instruments similar rules might apply. Maximum voltage of the beam does not exceed 30 kV in normal use. Licensing / registration might be required according to local regulations. For most of Europe no licensing/registration is necessary (see 96/29/Euratom directive, para. 3.2.e).

Safety

SITE REQUIREMENTS

Verify that the safety and environmental requirements of the workstation site, which are the responsibility of the customer, are satisfied. In particular, the pump exhaust requirements, the electrical supply and grounding (earthing) requirements, floor loading, and any local codes regarding earthquake safety are important safety issues.

If applicable, install a drip pan to collect potential oil spills and drips from the vacuum pumps.

EARTHQUAKE

Brackets included with the system during shipping can be used to secure the vacuum stand, extension cabinet, and operation and display console to the floor for greater safety during an earthquake.

These brackets in no way guarantee that during an earthquake you will not sustain damage or that local safety codes are met. As the design of these brackets are machine dependent, the details can be found in the relevant manual.

TRAINED, AUTHORIZED SERVICE PERSONNEL

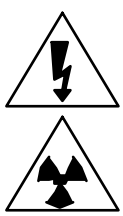
Before starting any service task on an FEI Company product, such as an electron microscope, ion beam equipment, any related accessories or third party equipment, the service engineer concerned must first have read and understood the relevant sections of the FEI Service Safety Manual.

Note:
Only service personnel certified by FEI are authorized to service the equipment.

A hardcopy of the FEI Service Safety Manual (order code number 4022 190 50058) is shipped with every FEI Company electron microscope or ion beam instrument and it is also present in electronic form on the FEI Customer Service CD-ROM. It contains explicit instructions on safe working methods, descriptions of the various warning symbols and labels used on FEI equipment, and Material Safety Data Sheets for all toxic gases and materials which may be present.

Read the following pages carefully before:

- installation
- service
- maintenance



D A N G E R !

These servicing instructions are for use by qualified personnel only. Do *not* perform any servicing other than that specified in the operating instructions unless you are fully qualified to do so.

FEI electron optical equipment is perfectly safe when correctly installed and operated. However, when inexpert modifications are made (for instance, the opening of covers or removal of parts, except those to which access can be gained by hand only), hazards such as:

- shock hazard
- radiation hazard
- EMC hazard
- mechanical hazard

can occur, which can result in personal injury or equipment damage if recommendations and instructions are not followed.

Any interruption of the protective conductor inside or outside the instrument, or disconnection of the protective earth terminal, is likely to make the instrument dangerous. Intentional interruption is prohibited.

Whenever a safety feature of the equipment has been impaired (e.g., by failing to perform the intended operation, or it is in a fault condition) the instrument ***MUST*** be made inoperative and secured against any unintentional operation. In all cases display a warning notice prominently. The matter should then be referred to the appropriate servicing authority.

USER MAINTENANCE

There may be additional limitations to safety and handling not mentioned in this manual. Never attempt maintenance or service of any kind on the electron column, other than that described for the user, in this User Manual.

Allow only trained personnel to perform user maintenance procedures. Always observe appropriate safety practices in dealing with electronic circuitry. Read and understand the safety precautions in this chapter and throughout the manual. Observe industry-approved safety methods and procedures.

If you have any doubt regarding approved safety procedures, contact safety personnel at your company, or representatives of your state, territory or province, or federal government.

General rules

- Do not service alone
- Do not perform internal service or adjustments unless you are a trained service person and unless another person, capable of rendering first aid or resuscitation, is in the immediate vicinity.
- Be aware of the location of the nearest phone.
- Be aware of the emergency services number. At the time of publishing, the following emergency service numbers were available:

TABLE 1-1 EMERGENCY TELEPHONE NUMBERS

Region	Number
America	911
United Kingdom	999
Europe (Not all countries)	112
……..…..…..…

MESSAGES

The following messages are used throughout the manuals:

Note:
Text of the note…..

A note emphasizes information requiring special attention.

C a u t i o n !
Text of the caution…..

A caution message appears where special handling is required to prevent product damage.

W A R N I N G !
Text of the warning…..

A warning message appears where special handling is required to prevent personal injury or death.

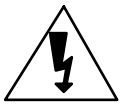
D A N G E R !
Text of the danger…..

A danger message identifies an immediate personal risk of injury or death and gives appropriate precautions.

SYMBOLS

The following symbols are used throughout the manuals:

TABLE 1-2 ICONS USED IN THE DOCUMENTATION:

Icon	Description
	High Voltage Care should be taken that danger voltages are being referred to
	Live part
	Read the operating instructions
	Protective earth (grounding) terminal
	Radiation danger
	ESD sensitive Care should be taken to protect these devices from electro static discharge.
	Keep these parts of the microscope clean and free of dust. Also to protect hands from cleaning agents, handle these parts only with gloves.
	Pinch hazard
	Flammable
	Corrosive

Lock Out / Tag Out (LOTO)
CONTROL OF HAZARDOUS ENERGIES

Purpose: This procedure is to establish the Lockout / Tagout requirements for FEI manufactured equipment and systems.

Scope: This procedure is intended for use to control hazardous energy sources during manufacturing and field service operations.

General Overview of LOTO

When to lockout

Lockout / Tagout the equipment you are working on when the service or maintenance operation will cause exposure to any form of hazardous energy. Examples of when to lockout include but are not limited to:

- Service and maintenance of any electrical circuits or components except those operations where the exposure is less than 24V.
- Service and maintenance where exposure to hazardous energies or conditions are present.

Forms of hazardous energies are shown in table TABLE 1-3.

TABLE 1-3 FORMS OF HAZARDOUS ENERGIES

Type of Energy	Description
1. Electrical	low voltage (50-600V), high voltage (>600V)
2. Chemical	explosion, pressure, extreme heat, fire, corrosive, reactive, oxidizer, toxic
3. Pressure	hydraulic, pneumatic
4. Vacuum	
5. Mechanical	capable of crushing, pinching, cutting, snagging, striking
6. Thermal, High Temperature	surface temperature, hot liquids, steam
7. Thermal, Cryogenic	contact with super cold surface or with a cryogenic liquid
8. Ionizing Radiation	
9. Non-ionizing	infra-red
10. Stored	flywheels, springs, differences in elevation, elevated parts that could drop, capacitors, batteries

Secure and Lockout / Tagout Procedure

1. Complete any operation in progress and bring the equipment to a safe shutdown condition. Switch the equipment off using the **OFF** switch.
2. Turn off power at disconnect points listed in TABLE 1-4, column 3.
3. LOTO or tag each energy control point listed in TABLE 1-4, column 3. Apply locks and tags per the facility lockout procedure.
4. Block any mechanical parts, remove any mechanical links. Lock blocking in place (TABLE 1-4, column 3).
   Note:
   Two physical blocks are required to break and secure any gas / liquid line.
5. Notify all affected personnel of LOTO. Verify personnel clear of hazards.
6. Ensure that all authorized employees working on the equipment have placed their locks and tags on the appropriate energy isolation device.
7. Dissipate / disconnect any stored energy (TABLE 1-4, column 5). Attempt to re-start machinery or re-energize equipment through normal means. Return switch back to OFF position.
8. Verify no hazardous energy. Use circuit tester / meter if electricity is involved (TABLE 1-4, column 5).
9. Perform required work.

Removing Lockout / Tagout and Restoring Operation

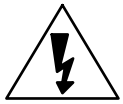
1. Upon completion of the activities requiring the lockout / tagout, secure all covers, restore all interlocks, and warn all affected employees that energy to the system will be restored. Verify that the danger zone is clear of equipment, tools, and test equipment.
2. Unlock and remove any blocking devices; remove linkages.
3. Remove all locks and tags from energy control points.
4. Reposition any safety devices.
5. Warn workers to stay clear of area. Verify that the area is clear of personnel.
6. Only the authorized employee may remove their lockout device, and only when the hazardous condition is no longer a threat. Reconnect the cord into the power receptacle or switch on the breaker.
7. Re-start/re-energize the equipment. Notify all affected and other persons that the lockout has been cleared.
8. The tool can now be restarted per recommended start up procedures.

TABLE 1-4 SPECIFIC PROCEDURES
HAZARDOUS ENERGIES CONTROL POINT LISTING

1. Energy Type	2. Danger Zone	3. Isolation Point (Include Locking point, Blocking point or Linkage removal point as applicable)	4. Point to disconnect / dissipate any stored energy	5. Method / place to verify no residual energy exists
1. Electrical	Main console and electrical cabinet	Mains power cord and plug	Disconnect cord and apply tag	Volt Meter Test
	EMO transformer / Power conditioner	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Volt Meter Test
	Power Distribution Box	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Volt Meter Test
	Vacuum System	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Volt Meter Test
	High Voltage System	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Volt Meter Test
	Deflection System	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Volt Meter Test
2. Chemical	Gas line on vacuum stand	Valve at the pressure gauge on the wall	Close valve	Reading on the pressure gauge on wall
3. Pressure	Gas line on vacuum stand	Valve at the pressure gauge on the wall	Close valve	Reading on the pressure gauge on wall
4. Vacuum	Vacuum chamber	Mains power cord and plug	Disconnect cord and apply tag	Vent chamber, open chamber door
5. Mechanical	Stage	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Verify the system power is removed
	Motorized valve	Mains power cord and plug	Disconnect cord and apply tag	Verify the system power is removed
6. Thermal	Wehnelt cylinder	Mains power cord and plug	Disconnect cord and apply tag	Verify the system power is removed
	Peltier stage	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Verify the system power is removed
	Hot stage	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Verify the system power is removed
7. Ionizing Radiation	Electron Column	Mains power cord and plug	Disconnect cord and apply tag	Verify the system power is removed
	Inside Chamber	Mains power cord and plug	Disconnect cord and apply tag	Verify the system power is removed
8. Non-Ionizing Radiation	Infra-red light on CCD camera	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Verify the system power is removed
9. Stored Energy	Charged capacitors	Mains power cord and plug or remove module from system	Disconnect cord and apply tag	Volt Meter Test

Electronics / Voltages

According to the American National Standards Institute (ANSI) guidelines, a shock hazard exists when voltage levels are present which are 30 V rms or 42.4 V peak. Use extreme caution whenever a shock hazard is present.



D A N G E R !

FEI components may have potentially lethal voltages (up to 30 kV).

As a good safety precaution, always expect a hazardous voltage in an unknown circuit before measuring.

Operators and service personnel must be trained on potential safety hazards and safe techniques, and must observe all warnings and cautions encountered on the system and in the manuals. No person should perform any operations without prior training.

ELECTRICAL PROCEDURE

Only authorized personnel are allowed to dismount panels from the microscope and its accessories and make voltage measurements. Remember: the voltage can be higher than expected and voltages can be hazardous. Therefore the following guidelines must be followed when making any voltage measurements:

- Never make these measurements when alone in a room.
- Never touch any parts that may be under high voltage.
- Connect the earth/ground/zero voltage probe **first** and disconnect it **last.**
- Use an **undamaged** voltmeter specified for at least 1 kV.
- Use **undamaged** probes specified for at least 1 kV.
- Never measure voltages above 500 V directly: in the electrical system a derivative of this voltage is always available.
- Where possible, regulate the voltage down before connecting or disconnecting the probe.
- Return the instrument to an electrically safe condition and make sure that all probes are detached after finishing the measurements. Mount all panels after finishing the job.

SAFETY INTERLOCKS

Components include safety interlocks to minimize high voltage hazards. Overriding interlocks is dangerous and should never be done by untrained personnel.

The Quanta has two human safety interlocks: the **Gun Lifts** for either column. Other interlocks are not intended to protect humans, but to prevent damage to the instrument during servicing.

The gun lift interlock switches off the beam voltage and thus enables safe handling of the Wehnelt during a filament change.

Note:
After completing procedures for which an interlock was disconnected, always reset (or reconnect) and test the interlock before proceeding. Do not turn the system on until you have made sure all connections are correct and secure.
Cover interlocks reset automatically when the covers are replaced.

EMO (EMERGENCY OFF)

The EMO is part of the SEMI S2 kit. The EMO circuit contains two EMO buttons. These buttons de-energize the microscope immediately.

FIGURE 1-1 LOCATION OF THE EMO BUTTONS

The working of the EMO circuitry has to be checked during the yearly maintenance of the microscope.

LINE VOLTAGE

Line voltage (120 to 240 V AC) may be present in various locations within the system, even when the system or instrument is turned off. Completely disconnect the unit from line voltage by disconnecting the AC plug from the AC power source before performing service or maintenance.

Note:
Service or troubleshooting in these areas should be performed only by an qualified service personnel.
Follow the LOTO procedure to lock out / tag out the instrument before servicing.

MISCELLANEOUS CORDS / CABLES

Check cables periodically for possible wear, cracks, or breaks. If any defects are found, replace with FEI approved cables.

Never connect or disconnect any cables or connections while power is applied to the system or components. Doing so is potentially hazardous to service personnel and could cause damage to the system or its components.

AC cables

Plug the unit AC cables only into an approved power source. Only use power cables that are in good condition. If replaced, use AC cables rated to at least the rating of the replaced AC cable.

The system main power should only be plugged into the approved power receptacle, as identified by system documentation.

Each power cable is labelled with a destination and origin and is colour-coded:

TABLE 1-5 AC CABLE CODING

North American Colour	International Colour	Meaning
Solid Green	Green with Yellow Stripe	Ground
Black	Brown	Line
White	Blue	Neutral

COLUMN POWER SUPPLIES

Wait 30 seconds to ensure all high voltage points are at ground potential before servicing equipment. The ion / electron power supplies take up to 30 seconds for high voltage to decay to 0 volts after being turned off.

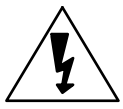
TEST LEADS

Only trained service persons should perform service on the system.

Inspect test leads for wear, cracks, and breaks before use. Replace any test leads showing such defects with test leads meeting the requirements called out by the manufacturer of the test instrument. Do not touch the test leads or the instrument while power is applied to a circuit under test.

GROUND (EARTH)

The focusing column and FEI electrical components must be grounded to operate safely. Do not defeat grounding or use an ungrounded power source. In the event of loss of a protective ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulated) can render an electric shock.



D A N G E R !
Do not exceed 30 volts rms between the input connector and ground. During testing, do not touch any object that could provide a current path to the common side of the circuit being tested or to earth ground.

Checking the protective ground connection

The correct connection and condition should be checked on a yearly basis by visual inspection and by measuring the resistance between the protective lead connection at the plug and the frame. This resistance must not exceed 0.1 Ohms. During measurement the mains cable should be moved: resistance variations indicate a defect.

COVER / PANELS

Do not operate or plug in any electrical unit without the protective covers or panels installed. Only qualified persons aware of the electrical hazards should perform maintenance or service operations.

FUSES

Only trained service personnel should replace fuses. Replace fuses only with fuses of the same type, voltage rating, and current rating.

REPLACEMENTS

Standard electrical and mechanical replacement parts can be obtained through your local FEI organization or representative. Components in the primary circuit may only be replaced by components selected by FEI. However, many of the standard electronic components can be obtained from other local suppliers. Before purchasing or ordering replacement parts, check the parts list for value, tolerance, rating and description.

Note:
Physical size and shape of a component may affect instrument performance, particularly at high frequencies. Always use direct replacement components unless it is known that a substitute will not degrade instrument performance.

WARNING!

Handle silicon heatsink compound with care. Avoid contact with the eyes. Wash hands thoroughly after use.

STATIC-SENSITIVE COMPONENTS

This instrument contains electrical components that are susceptible to damage from electrostatic discharge (ESD). Servicing ESD sensitive assemblies or components should be performed only at a static-free work station by qualified service personnel.

Radiation

W A R N I N G !
Only authorized personnel are allowed to perform radiation checks.

The radiation checks that are to be carried out are machine dependent. See the appropriate manual for instructions and limits.

Local regulations may require that an X-ray check is performed by an authorized body after installation and / or maintenance or service actions. Check the local regulations. Otherwise a check by FEI service personnel is advised, using e.g. the Victoreen 190 radiation detector.

X-RAY SAFETY

W A R N I N G !
After dismantling or assembling the column it is mandatory to check for X-Ray leakage.
The X-Ray leak may never exceed 1 µSv/h at 10 cm distance. Measurements must be made by qualified personnel. As a measuring instrument use the Victoreen 190 X-ray meter with detector RP1 and the Basics of Radiation Protection manual, order number 4822 870 10412, obtainable via the Helpdesk.

W A R N I N G !
Under no circumstances should the HV be switched on when using vacuum test flanges.

RADIATION MEASUREMENT

- The Victoreen 190+RP1 has been chosen as the X-ray survey meter.
- Any problems should be communicated to the Radiation Safety Officer.
- If a problem is caused by a standard FEI/Philips part, use the principle of ALARA (As Low As Reasonable Achievable) to reach a solution.
- It is important not to expose the user (including yourself) to unnecessary radiation.
- All service engineers must use the X-ray radiation survey equipment provided to them. The equipment must have been calibrated according to the equipment calibration procedure.

Chemicals

WARNING!

- Always check the safety warnings before using any chemicals. Be aware of hazards and how to avoid them (see the relevant Material Safety Data Sheets – MSDS).

- Volatile and corrosive substances can diffuse through contact lenses despite reasonably well ventilated conditions. Moreover, contact lenses are difficult to remove when an irritant chemical enters the eye, making irrigation ineffective. Care must be taken to address the issue of contact lens worn by those coming into contact with such solvent fumes.

The following substances are used on the equipment:

- **Oils:** Ultragrade 19 (lubricating oil)
- **Greases:** Molykote BR2 plus
  Fomblin RT 15 (Fluoropolyether grease)
- **Solvents:** De-ionized or distilled water
  Ethanol - C_2H_5OH
  Ethanol Pro-Analysis (99.8% pure) - C_2H_5OH *)
  KOH *) (Potassium Hydroxide)
  NaOH *) (Sodium Hydroxide)
  EXTRAN - MA02 *) (neutral cleaning fluid)
  CIF (household fine abrasive cleaner)

Note:
the above-mentioned solvents are the only ones recommended by FEI/Philips. The products marked by *) are supplied by:

E. MERCK
Darmstadt
W. Germany

Cleaning - Code of Practice

- Do not open the column unless it is really necessary, but check the performance regularly.
- Always work in a clean and ***ventilated*** room.
- Use a clean working table with good illumination.
- Wear lint-free clothes.
- Always wear clean gloves when handling “vacuum” parts.
- Collect all cleaning items and have them on site before opening the column.
- Always use ***clean*** solvents.
- Use chemicals carefully and in sparing quantities. Avoid spillage, skin contact, eye contact, and vapour inhalation.
- Do not mix materials of different compositions in the cleaning baths.
- Before mounting, inspect parts under a light microscope.
- Be sure that special tools are clean before use and packed after use in aluminium foil.
- Strip the assemblies as far as possible.
- Pack items in aluminium foil after cleaning.
- Vacuum parts that can not be remounted immediately can best be kept under an infrared lamp and wrapped in aluminium foil.

GASSES

Nitrogen (N_2)

For all microscopes, nitrogen is used to vent the chamber and vacuum system. Although Nitrogen is not poisonous it is a potential asphyxiant.

Liquid Nitrogen (LN_2)

Optionally the EDAX detecting unit is mounted on the microscope. The EDAX unit has a 10 liter dewar vessel, containing liquid nitrogen.

Only authorized personnel should carry out replenishment, and the MSDS for liquid nitrogen should be read and understood.

W A R N I N G !

- Suffocation is possible if nitrogen or liquid nitrogen is released in an enclosed room without adequate ventilation.
- Liquid nitrogen has the potential to cause frostbite if direct contact with skin occurs.
- On standing, liquid nitrogen absorbs oxygen from the air and forms liquid oxygen in solution. Treat any liquid nitrogen that is not fresh as though it had all the hazards of liquid oxygen.
- Use a safety approved step ladder to reach the opening when refilling the liquid nitrogen, if necessary.

OTHER GASSES

Auxiliary Gas Inlet

The Quanta microscope is configured with an auxiliary gas inlet. If the customer decides to use this inlet, FEI then advises the use of inert (non-hazardous, non-flammable, non-corrosive and non-reactive) gasses, which are not decomposed by the electron beam or the X-rays generated thereby.

If gasses other than inert ones are used, FEI COMPANY expressly denies any responsibility and will not be held liable for any damage or risks resulting from the improper use of the gas inlet.

FEI then advises that the customer perform a complete H&S (health & safety) risk evaluation, with special emphasis on toxicity, emission to the environment, etc, keeping in mind the reactivity with pump oils and several types of metals, polymers and greases used within the vacuum chamber, the use of high voltages, the generation of X-rays and charged particles (electrons) which can lead to decomposition of gases, the impact of heating stage utilization on particular substances and local permits.

C a u t i o n !

Maximum overpressures for the auxiliary gas inlet and the nitrogen inlet are each 0.1 atm above atmospheric pressure.

MATERIAL SAFETY DATA SHEETS (MSDS)

C a u t i o n !

The MSDS refered to in this document are only examples. The engineer / user must be aware that the information in an MSDS can vary depending on the country. During an emergency the engineer / user must refer to the local MSDS.

Dispose of chemicals, such as oils, greases or computer batteries, following local regulations and procedures.

- **List of MSDS for the chemicals (trade names):**
  MOLYKOTE BR 2 Plus, 01,
  FOMBLIN RT 15,
  ULTRAGRADE 19,
  NITROGEN 10, LIQUID, 01

FIGURE 1-2 MSDS OF THE ABOVE-MENTIONED CHEMICALS

MATERIAL SAFETY DATA SHEET
According EC 91/155

1. Identification of the substance/preparation

MSDS : 02721
Product code 12nc : 1322 502 72801
Supplier : DOW CORNING
62, RUE GENERAL DE GAULLE
1310 TERHULPEN
Belgium
Tel: +32-2-655-2523
Fax: +32-2-655-2002
Tradename : MOLYKOTE BR 2 PLUS. 01
General description : GREASE
Use : Miscellaneous
Publicationdate : 1995-04-18
Emergency phonenumber +31 (0)497-598315

2. Composition/information on ingredients

Component	CAS-number	EC-number	Percentage	EC-label
MINERAL OIL				
MOLYBDENUMDISULFIDE	1317-33-5	215-263-9		
LITHIUM SOAP				
CORROSION PREVENTIVES				

3. Hazard identification

4. First-aid measures

Skin : Remove residue substance as soon as possible from the skin (f.i. rinse with much water).
Ingestion : Let drink 1 or 2 glasses of water. In case of general disorders call for a doctor.
Inhalation : Not applicable.
Eyes : Rinse for a long time with much water. In case of eye-sight disturbances consult a doctor.
Remarks first aid : none

5. Fire fighting measures

Fire-extinguisher : carbon dioxide, water spray, foam, extinguishing powder
Hazardous decomposition products in fire : carbon monoxide, sulphur compounds

6. Accidental release measures

Spillage procedure : Dependent on quantity spilt paste, one has the choice between: - remove with cleaning rag or paper, or - cover paste with Powersorb, sand, diatomite, vermiculite and suchlike. Shovel the material into plastic bag or other suitable packaging and remove to the central depot for hazardous waste.
Emergency procedure : not applicable

7. Handling and storage

Local exhausting : Under normal circumstances not applicable.
Storage conditions : Store product at a cool and dry place.
Keep packing closed.

8. Exposure controls/personal protection

Exposure limits :		
TLV:	5 mg/m3	MINERAL OIL(as oil aerosol)
	applicable to: Netherlands (20 °C; 1013 mbar)	
TLV:	5 mg/m3	MINERAL OIL(as oil aerosol)
STEL:	10 mg/m3	MINERAL OIL(as oil aerosol)
	applicable to: Belgium (20 °C; 1013 mbar)	
TLV:	10 mg/m3	MOLYBDENUMDISULFIDE(as molybdene)
	applicable to: Netherlands (20 °C; 1013 mbar)	
TLV:	10 mg/m3	MOLYBDENUMDISULFIDE(as molybdene)
	applicable to: Belgium (20 °C; 1013 mbar)	
TLV:	10 mg/m3	MOLYBDENUMDISULFIDE(as molybdene, inhalable dust)
	applicable to: United States (25 °C; 1013 mbar)	
TLV:	3 mg/m3	MOLYBDENUMDISULFIDE(as respirable dust)
	applicable to: United States (25 °C; 1013 mbar)	
TLV:	3 mg/m3	MOLYBDENUMDISULFIDE(as molybdene)
	applicable to: Germany (20 °C; 1013 mbar)	
not determined		LITHIUM SOAP
not determined		CORROSION PREVENTIVES

Inner company references : none

Overview relevant R-sentences from all components in section 2 :
not applicable

Date last update : 1995-04-18

* Point to alterations with regard to the previous version.
The information provided in this Material Safety Data Sheet is correct to the best of the knowledge, information and belief of Philips Electronics Nederland B.V. at the date of its printing.

C=Ceiling; S=Skin

Remarks exposure limits :
none

Odour threshold (20ºC; 1013 mbar) :
not traceable

Advised personal protection :

skin	:	butyl rubber gloves
eyes	:	safety goggles
inhalation	:	none (when sufficient exhausting)

9. Physical and chemical properties

Physical state	:	paste
Colour	:	grey
Odour	:	oily
Vapor rate/range		not traceable
Boiling point/range	:	≥150 ºC (1013 mbar)
Melting point/range	:	not traceable
Flash point/range	:	≥100 ºC
Explosive limits	:	not applicable
Dust explosions possible in air	:	not applicable
Relative density	:	0,89000 (water=1) (20 ºC)
Vapour pressure	:	<0,7 kPa (20 ºC)
Solubility in water	:	none
Solubility in fat	:	not traceable
pH	:	not applicable
Viscosity	:	not traceable
Autoignition temperature	:	not traceable
Decomposition temperature	:	not traceable
Electrostatic chargement	:	yes

10. Stability and reactivity

Conditions to avoid	:	none
Reactions with water	:	no
Hazardous reactions with	:	oxidizing substances
Hazardous decomposition products at heating	:	not tracable

11. Toxicological information

Symptoms

Skin	local	:	Produces no symptoms.
	general	:	Not applicable.
Ingestion	local	:	No symptoms under normal working conditions.
	general	:	No absorbtion worth mentioning under normal working conditions.
Inhalation	local	:	Not applicable.
	general	:	Not applicable.
Eyes	local	:	The substance is prickling: redness.
Remarks symptoms		:	None
Toxicity		:	not traceable

12. Ecotoxicological information

Biological oxygen demand (5)	:	not traceable
Chemical oxygen demand	:	not traceable
Biological/chemical oxygen demand ratio	:	not traceable
Biochemical factor	:	not traceable
Log Po/w	:	not traceable
Ecotoxicity	:	not traceable
Remarks on ecotoxicity	:	none

13. Disposal considerations

Remainder material or uncleaned empty packagings have to be incinerated in a proper installation or dumped on an approved landfill, in accordance with local and national legislation. Consider also return delivery to supplier.

14. Transport information

Not subject to Transport-regulation Dangerous Substances

15. Regulatory information

EC-Label	:	not applicable
Remarks on EC-labeling	:	none

16. Other information

Remarks on MSDS	:	none

MATERIAL SAFETY DATA SHEET

According EC 91/155

1. Identification of the substance/preparation

MSDS : 11284
Product code 12nc : 1322 518 87401
Supplier : SOLVAY SOLEXIS
Viale Lombardia, 20
1-20021 Bollate MI Milan
Italy
Tel: +39-2-38351
Fax: +39-2-38352110
Tradename : FOMBLIN RT 15
General description : FLUOROPOLYETHER GREASE
Use : Miscellaneous
Publicationdate : 1996-07-15
Emergency phonenumber +31 (0)497-598315

2. Composition/information on ingredients

Component	CAS-number	EC-number	Percentage	EC-label
TEFLON	9002-84-0		30.0 %	
PERFLUOROPOLYETHER	69991-67-9		70.0 %	

3. Hazard identification

4. First-aid measures

Skin : Remove residue substance as soon as possible from the skin (f.i. rinse with much water).
Ingestion : Let drink 1 or 2 glasses of water. In case of general disorders call for a doctor.
Inhalation : Not applicable.
Eyes : Rinse for a long time with much water. In case of eye-sight disturbances consult a doctor.
Remarks first aid : none

5. Fire fighting measures

Fire-extinguisher : water spray, extinguishing powder, foam, carbon dioxide
Hazardous decomposition products in fire : carbon monoxide, hydrogen fluoride

6. Accidental_release measures

Spillage procedure : Dependent on quantity spilt paste, one has the choice between: - remove with cleaning rag or paper, or - cover paste with Powersorb, sand, diatomite, vermiculite and suchlike. Shovel the material into plastic bag or other suitable packaging and remove to the central depot for hazardous waste.
Emergency procedure : not applicable

7. Handling and storage

Local exhausting : Under normal circumstances not applicable.
Storage conditions : Keep packing closed.
Store product at a cool place.

8. Exposure controls/personal protection

Exposure limits :

not determined	TEFLON
not determined	PERFLUOROPOLYETHER
C=Ceiling; S=Skin	

Remarks exposure limits :
none
Odour threshold (20°C; 1013 mbar) :
not traceable
Advised personal protection :
skin : butyl rubber gloves
eyes : safety goggles
inhalation : none (when sufficient exhausting)

9. Physical and chemical properties

Physical state : paste
Colour : white
Odour : odourless
Vapor rate/range : not traceable
Boiling point/range : The product decomposes before it boils.
Melting point/range : not traceable
Flash point/range : not applicable
Explosive limits : not applicable
Dust explosions possible in air : not applicable
Relative density : 1,90000 (water=1) (20 °C)
Vapour pressure : negligible
Solubility in water : none
Solubility in fat : not traceable
pH : not applicable
Viscosity : not traceable
Autoignition temperature : not applicable
Decomposition temperature : >260 °C
Electrostatic chargement : no

10. Stability and reactivity

Conditions to avoid : none
Reactions with water : no
Hazardous reactions with : strong alkaline solutions
Hazardous decomposition products at heating : carbonyl fluoride, perfluoroisobutylene

11. Toxicological information

Symptoms

Skin	local	With intensive skin contact risk of skin affection.
	general	Not applicable.
Ingestion	local	Produces no symptoms.
	general	Not applicable.
Inhalation	local	The decompositon products are irritating: sore throat, coughing, dyspnoea.
	general	See remarks symptoms.
Eyes	local	The substance is prickling: redness.
Remarks symptoms		The decomposition products are adsorbed: polymer vapour fever.

Toxicity : LD-50: >2 g/kg (ORL-RAT), PERFLUOROPOLYETHER

12. Ecotoxicological information

Biological oxygen demand (5) : not traceable
Chemical oxygen demand : not traceable
Biological/chemical oxygen demand ratio : not traceable
Biochemical factor : not traceable
Log Po/w : not traceable
Ecotoxicity : not traceable
Remarks on ecotoxicity : none

13. Disposal considerations

Remainder material or uncleaned empty packagings have to be incinerated in a proper installation or dumped on an approved landfill, in accordance with local and national legislation. Consider also return delivery to supplier.

14. Transport information

Not subject to Transport-regulation Dangerous Substances

15. Regulatory information

EC-Label : not applicable
Remarks on EC-labeling : none

16. Other information

Remarks on MSDS : none
Inner company references : BXV 11-6

Overview relevant R-sentences from all components in section 2 :
not applicable

Date last update : 1996-07-15

* Point to alterations with regard to the previous version.
The information provided in this Material Safety Data Sheet is correct to the best of the knowledge, information and belief of Philips Electronics Nederland B.V. at the date of its printing.

MATERIAL SAFETY DATA SHEET

According EC 91/155

1. Identification of the substance/preparation

MSDS : 12084
Product code 12nc : 1322 525 82201
Supplier : EDWARDS
MANOR ROYAL
CRAWLEY
WEST SUSSEX RH10 2LW
United Kingdom
Tel: +44-1293-528844
Fax: +44-1293-533453
Tradename : ULTRAGRADE 19
General description : LUBRICATING OIL
Use : Miscellaneous
Publicationdate : 1998-10-22
Emergency phonenumber +31 (0)497-598315

2. Composition/information on ingredients

Component	CAS-number	EC-number	Percentage	EC-label
LUBRICATING OILS(PETR.),C20-C50,HYDR., HIGH VISC	72623-85-9	276-736-3		
LUBRICATING OILS (PETR.), C20-C50, HYDROTREATED	72623-87-1	276-738-4		

3. Hazard identification

4. First-aid measures

Skin : Remove residue substance as soon as possible from the skin (f.i. rinse with much water).
Ingestion : If victim is conscious, rinse mouth with water. DO NOT let drink. DO NOT induce vomiting. Bring victim as soon as possible into the hospital
Inhalation : Bring the victim into the fresh air as soon as possible, let rest and if necessary call for a doctor.
Eyes : Rinse for a long time with much water. In case of eye-sight disturbances consult a doctor.
Remarks first aid : none

5. Fire fighting measures

Fire-extinguisher : water spray, foam, extinguishing powder, carbon dioxide
Hazardous decomposition products in fire : carbon monoxide

6. Accidental_release measures

Spillage procedure : Absorb the liquid in appropriate absorbent (e.g. Powersorb, dry sand, diatomite, vermiculite etc.), shovel the mixture into plastic bags and remove to the central depot for hazardous waste.
Emergency procedure : not applicable

7. Handling and storage

Local exhausting : Under normal circumstances not applicable.
Storage conditions : no special precautions

8. Exposure controls/personal protection

Exposure limits :

TLV:	5 mg/m3	LUBRICATING OILS(PETR.),C20-C50,HYDR., HIGH VISC(as oil aerosol)
	applicable to: Netherlands (20 °C; 1013 mbar)	
TLV:	5 mg/m3	LUBRICATING OILS(PETR.),C20-C50,HYDR., HIGH VISC(as oil aerosol)
STEL:	10 mg/m3	LUBRICATING OILS(PETR.),C20-C50,HYDR., HIGH VISC(as oil aerosol)
	applicable to: Belgium (20 °C; 1013 mbar)	
TLV:	5 mg/m3	LUBRICATING OILS (PETR.), C20-C50, HYDROTREATED(as oil aerosol)
	applicable to: Netherlands (20 °C; 1013 mbar)	
TLV:	5 mg/m3	LUBRICATING OILS (PETR.), C20-C50, HYDROTREATED(as oil aerosol)
STEL:	10 mg/m3	LUBRICATING OILS (PETR.), C20-C50, HYDROTREATED(as oil aerosol)
	applicable to: Belgium (20 °C; 1013 mbar)	

C=Ceiling; S=Skin

Remarks exposure limits :
none
Odour threshold (20°C; 1013 mbar) :
not traceable
Advised personal protection :

skin	:	polyvinyl alcohol gloves
eyes	:	safety goggles
inhalation	:	none (when sufficient exhausting)

9. Physical and chemical properties

Physical state	:	liquid
Colour	:	colourless / yellow
Odour	:	odourless
Vapor rate/range		not traceable
Boiling point/range	:	380 °C (1013 mbar)
Melting point/range	:	not traceable
Flash point/range	:	200 °C
Explosive limits	:	not applicable
Dust explosions possible in air	:	not applicable
Relative density	:	0,86000 (water=1) (20 °C)
Vapour pressure	:	0,003 kPa (20 °C)
Solubility in water	:	none
Solubility in fat	:	not traceable
pH	:	not applicable
Viscosity	:	not traceable
Autoignition temperature	:	355 °C
Decomposition temperature	:	not traceable
Electrostatic chargement	:	not traceable

10. Stability and reactivity

Conditions to avoid	:	Excessive heat.
Reactions with water	:	no
Hazardous reactions with	:	strong oxidizers, strong acids, chlorine
Hazardous decomposition products at heating	:	none

11. Toxicological information

Symptoms

Skin	local	:	With intensive skin contact risk of skin affection.
	general	:	Not applicable.
Ingestion	local	:	The substance is prickling: diarrhoea.
		:	No symptoms under normal working conditions.
	general	:	No absorbtion worth mentioning under normal working conditions.
Inhalation	local	:	The substance is with atomizing in large concentrations prickling: coughing.
	general	:	Probably no absorbtion worth mentioning.
Eyes	local	:	The substance is prickling: redness, pain.
Remarks symptoms		:	None
Toxicity		:	not traceable

12. Ecotoxicological information

Biological oxygen demand (5)	:	not traceable
Chemical oxygen demand	:	not traceable
Biological/chemical oxygen demand ratio	:	not traceable
Biochemical factor	:	not traceable
Log Po/w	:	≥3.9 -≤6 LUBRICATING OILS(PETR.),C20-C50,HYDR., HIGH VISC ≥3.9 -≤6 LUBRICATING OILS (PETR.), C20-C50, HYDROTREATED
Ecotoxicity	:	LC-50: >1000 mg/l/96H (Fish), LUBRICATING OILS(PETR.),C20-C50,HYDR., HIGH VISC EC-50: >1000 mg/l/48H (Daphnia), LUBRICATING OILS(PETR.),C20-C50,HYDR., HIGH VISC LC-50: >1000 mg/l/96H (Fish), LUBRICATING OILS (PETR.), C20-C50, HYDROTREATED EC-50: >1000 mg/l/48H (Daphnia), LUBRICATING OILS (PETR.), C20-C50, HYDROTREATED
Remarks on ecotoxicity	:	none

13. Disposal considerations

Remainder material or uncleaned empty packagings have to be incinerated in a proper installation or dumped on an approved landfill, in accordance with local and national legislation. Consider also return delivery to supplier.

14. Transport information

Not subject to Transport-regulation Dangerous Substances

15. Regulatory information

EC-Label : not applicable
Remarks on EC-labeling : none

16. Other information

Remarks on MSDS : The components, as mentioned in section 2, are registrated in the Toxic Substances Control Act Inventory (USA).
Inner company references : none

Overview relevant R-sentences from all components in section 2 :
not applicable

Date last update : 1998-10-22

* Point to alterations with regard to the previous version.
The information provided in this Material Safety Data Sheet is correct to the best of the knowledge, information and belief of Philips Electronics Nederland B.V. at the date of its printing.

MATERIAL SAFETY DATA SHEET

According EC 91/155

1. Identification of the substance/preparation

MSDS : 00344
Product code 12nc : 1313 503 23601
Chemical name : NITROGEN, REFRIGERATED LIQUID
EC-number : 231-783-9
Formula : N_2
Use : Miscellaneous
Publicationdate : 2002-09-02
Emergency phonenumber +31 (0)497-598315

2. Composition/information on ingredients

Component	CAS-number	EC-number	Percentage	EC-label
NITROGEN, REFRIGERATED LIQUID	7727-37-9	231-783-9	100.0 %	R: 99

3. Hazard identification

R-phrases
- Suffocating in high concentrations.

4. First-aid measures

Skin : In case of freezing DO NOT remove contaminated clothes. In case of burnings always call for a doctor
Ingestion : Not applicable.
Inhalation : Bring victim into the fresh air as soon as possible and let rest. In case of severe exposure call for a doctor. In case of breathing problems, loose squeezing clothes and if victim is conscious bring victim in high sitting position. In case of stagnation of breathing give IMMEDIATELY oxygen and transport to hospital as soon as possible.
Eyes : Not applicable.
Remarks first aid : none

5. Fire fighting measures

Fire-extinguisher : determined by surrounding
Hazardous decomposition products in fire : nitrous oxides

6. Accidental_release measures

Spillage procedure : Stop gas stream, warn fire brigade.
Emergency procedure : not applicable

7. Handling and storage

Local exhausting : Depends on processing circumstances, but at least good room ventilation.
Storage conditions : Keep container in a well-ventilated place.
Keep packing closed and dry.
Storage temperature : <50 °C

8. Exposure controls/personal protection

Exposure limits :

not determined	NITROGEN, REFRIGERATED LIQUID
not determined	NITROGEN, REFRIGERATED LIQUID
C=Ceiling; S=Skin	

Remarks exposure limits :
none
Odour threshold (20°C; 1013 mbar) :
not traceable
Advised personal protection :
skin : cold-isolating gloves
eyes : face mask
inhalation : none (when sufficient exhausting)
see info. section 16 SDS
No Filtermask

9. Physical and chemical properties

Physical state : liquid gas, refrigerated
Colour : colourless
Odour : odourless
Vapor rate/range : not traceable
Boiling point/range : -196 °C (1013 mbar)

16. Other information

Remarks on MSDS : In extreme circumstances and at emergency response, use independent inhalation protection.
The critical temperature is -147 degrees Celsius.
Inner company references : BXV 10-2

Overview relevant R-sentences from all components in section 2 :
99 Suffocating in high concentrations.

Date last update : 2003-03-05

* Point to alterations with regard to the previous version.
The information provided in this Material Safety Data Sheet is correct to the best of the knowledge, information and belief of FEI ELECTRON OPTICS B.V. at the date of its printing.

Melting point/range : -210 °C
Flash point/range : not applicable
Explosive limits : not applicable
Dust explosions possible in air : not applicable
relative vapour density : 0.97000 (air=1) (20 °C)
Vapour pressure : not traceable
Solubility in water : none
Solubility in fat : not traceable
pH : not applicable
Viscosity : not applicable
Autoignition temperature : not traceable
Decomposition temperature : not traceable
Electrostatic chargement : no

10. Stability and reactivity

Conditions to avoid : none
Reactions with water : no
Hazardous reactions with : lithium, alkaline earth metals
Hazardous decomposition products at heating : none

11. Toxicological information

Symptoms

Skin	local	:	In case of freezing: redness, pain, burns.
	general	:	Not applicable.
Ingestion	local	:	Not applicable.
	general	:	Not applicable.
Inhalation	local	:	Produces no symptoms.
	general	:	The substance may be absorbed after inhalation.
		:	Large concentrations may cause: headache, drowsiness, dizziness, nausea, unconsiousnes
Eyes	local	:	In case of freezing: redness, pain, poor vision.
Remarks symptoms		:	Oxygen displacing gas: liberating this gas may have an asphyxiating effect by displacement air.

Toxicity : not traceable

12. Ecotoxicological information

Biological oxygen demand (5) : not traceable
Chemical oxygen demand : not traceable
Biological/chemical oxygen demand ratio : not traceable
Biochemical factor : not traceable
Log Po/w : not traceable
Ecotoxicity : not traceable
Remarks on ecotoxicity : none

13. Disposal considerations

Remainder material or uncleaned empty packagings have to be incinerated in a proper installation or dumped on an approved landfill, in accordance with local and national legislation. Consider also return delivery to supplier.

14. Transport information

*** ADR/RID**	**UN-number**	:	1977 NITROGEN, REFRIGERATED LIQUID
	Class	:	2.2
	Packinggroup	:	none
	Transport emergency card	:	20S1977
*** IMO**	**UN-number**	:	1977 NITROGEN, REFRIGERATED LIQUID
	Class	:	2.2
	Packinggroup	:	none
	Marine pollutant	:	no
*** IATA/ICAO**	**UN-number**	:	1977 NITROGEN, REFRIGERATED LIQUID
	Class	:	2.2
	Packinggroup	:	none

15. Regulatory information

Hazard symbol
none
R-phrases
99 Suffocating in high concentrations.
S-phrases
9 Keep container in a well-ventilated place.
23.1 Do not breathe gas.
Hazardous component(s) : NITROGEN, REFRIGERATED LIQUID
Remarks on EC-labeling : none

Recycling / Reuse Information

All parts of the Quanta microscope can be recycled or reused, subject to local regulations.

With the exception of the pre-vacuum oil Ultragrade 19 (contained in the prevacuum pump), there are no materials contained in the microscope uncommon to standard electronic equipment.

Please contact the FEI company for any further information regarding reuse.

Miscellaneous Precautions

ELECTRIC FANS

Some instruments in the system may be air-cooled. Do not block the air flow to or from the fans. Do not operate fans with the protective covers or filters removed. Keep fingers, loose clothing, etc. away from fans. Periodic filter maintenance may be required to prevent overheating.

PUMP EXHAUST

Failure to provide proper exhaust filtering may discharge oil mist into the environment. Such oil mist may be an environmental hazard as well as a health hazard in an enclosed room.

CORROSION

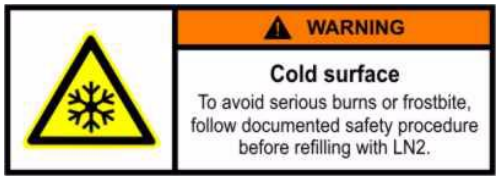
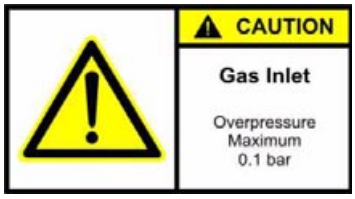
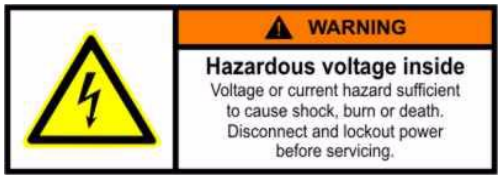
Components are painted, plated, or otherwise treated to resist corrosion. However, the components must be handled and stored properly to prevent corrosion. Observe precautions carefully.

Labels

The number and position of labels on the microscope can vary according to the country, configuration and accessories of the microscope.

- A yellow caution message appears where special handling is required to prevent product damage.
- An orange warning message appears where special handling is required to prevent personal injury or death.
- A red danger message identifies an immediate personal risk of injury or death and gives appropriate precautions.

TABLE 1-6 LABELS USED ON THE MICROSCOPE BODY

Label	Description
	**Extremely low temperatures** may be present on parts of the microscope. Precautions must be taken where this sticker is visible.
	Extremely high temperatures may be present on parts of the microscope. Take necessary precautions
	**High pressure** may be present. Take necessary precautions
	**Lethal voltages** may be present on parts of the microscope. Take necessary precautions.
	Magnetic Field may be present which can be harmful to pacemaker wearers. Pacemaker wearers should stay back at least 15 cm (6").
	Moving parts may be present. Take precautions when working in those areas to ensure that hair and loose clothing are restrained.

More information about safety when working and maintaining the microscopes can be found in the document entitled “Service Safety Manual Quanta”.

2 SYSTEM OVERVIEW

The Quanta 3D System Capabilities

The Quanta 3D DualBeam® is a combination of two systems:

- SEM is an electron microscope that produces enlarged images of a variety of specimens achieving magnification over 100 000x providing high resolution imaging in a digital format,
- FIB is an ion beam system that is capable of fast and precise milling of the specimen material, revealing the structure under the surface layer, making cross sections, deposition layers, etc. The ion system produces high resolution images as well.

The integration of both systems yields a powerful analytical tool for obtaining any data from any sample in three dimensions.

Users can switch between the two beams for quick and accurate navigation and milling. Convergence of the SEM and FIB at a short working distance allows precision “slice-and-view” cross-sectioning and analysis at high resolution. The workstation provides optimum throughput, resolution and automation.

FIB/SEM workstations provide an expanded range of capabilities not possible with separate FIB and SEM tools:

- High-resolution electron beam images of FIB cross sections without eroding the feature of interest
- Real-time cross-section images and videos with the electron beam during FIB milling
- Focused electron beam charge neutralization during FIB milling
- High resolution elemental microanalysis of defect cross sections
- Imaging of sample surfaces with the electron beam during navigation without erosion or gallium implantation from the ion beam
- TEM sample preparation with *in situ* conductive coating

How Quanta 3D Works

Four main components combine to produce images from the sample:

- **Electron and/or ion gun**
  The gun can be a source of electrons or ions (particles). The beam is emitted within a small spatial volume with a small angular spread and selectable energy.
- **Optical system**
  The beam enters the optical system consisting of several electron or ion lenses and exits to hit the specimen surface. Particles striking the specimen react with atoms of the sample surface in different manners.
  The electron beam produces three basic types of signal: X-rays, electrons and photons. The ion beam produces ions and electrons.
- **Scan unit**
  The scan generator signal, fed to the deflection systems, moves the beam in a raster pattern over the specimen area. The electrical voltage changes as it rasters, which provides serial information of the specimen surface. This signal, modulated by the one from the detection system, produces the onscreen image.
- **Detection unit**
  The detector system picks up the particles, converts them into an amplified electrical signal which is then sent to the control PC and displayed on the monitor.

FIGURE 2-1 SEM SCHEMATIC OVERVIEW

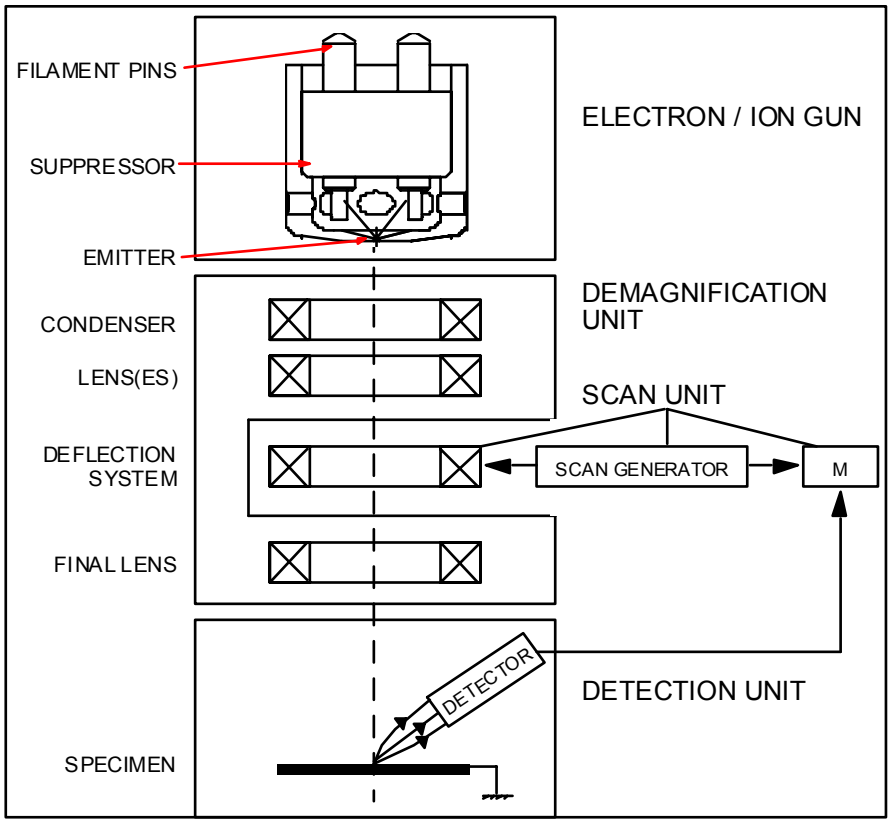


IMAGE VIEWING AND CAPTURE

Magnification is the ratio of the size of the viewing monitor screen to the size of the area scanned on the specimen. Increased magnification is achieved by reducing the size of the area scanned on the specimen.

Digital scanning provides a completely digital image, and image capture is performed by scanning one frame a time at a High resolution of pixel format.

CONTROL OF THE BEAMS

FIB/SEM workstations position the point of interest ideally for simultaneous ion beam cross-sectioning and electron beam viewing. Separate scan generators for the two beams permit coupled or independent scan patterns and magnifications. Imaging while milling aids in defining milled features.

Immediate electron beam images of cross sections are possible without stage motion or sample transfer. Immediate high-resolution SEM imaging after FIB milling also prevents exposure of milled cross sections to atmospheric contaminants.

GAS DEPOSITION

Multiple gas injectors can be installed for material deposition in conjunction with either electron or ion beam pattern definition. Electron beam-induced deposition offers the advantage of not sputtering the deposited material or implanting gallium simultaneously.

Gas Enhanced Etch

FEI's Gas Injection System (GIS) also provides Enhanced Etch™ capability for high aspect ratio drilling with minimal redeposition, as well as metal deposition, preferential etching of cross-section surfaces prior to SEM imaging, and rapid milling of TEM sections.

Up to two GIS beam chemistries can be installed on the workstation, depending on system configuration. This self-contained apparatus allows the precursor material to be contained entirely within the vacuum system for simple, flexible, and safe operation.

X-RAY ANALYSIS CAPABILITY

Energy Dispersive X-ray (EDX) provides elemental analysis capability for identification of surface and subsurface features. Convergence of the SEM, FIB, and EDX at short working distance allows precision "slice-and-view" cross-sectioning and chemical analysis at high resolution. Various vendor options are compatible with the workstation.

SYSTEM VACUUM

The entire electron or ion path from gun to specimen must be under vacuum so the particles won't collide with air molecules and be absorbed. Various levels of vacuum are necessary, so a Turbo Molecular Pump (TMP) and Ion Getter Pump (IGP) backed by a rotary pre-vacuum pump, obtains the necessary specimen chamber vacuum. The exceptions to this rule are the LowVac and ESEM modes associated with the Quanta Series where water vapor or gas is introduced to the specimen chamber. The Quanta 3D has 3 operating vacuum modes to deal with different sample types:

- **High Vacuum (HiVac)** is the conventional operating mode associated with all scanning electron microscopes.
- **Low Vacuum** (LowVac)
- **ESEM**™

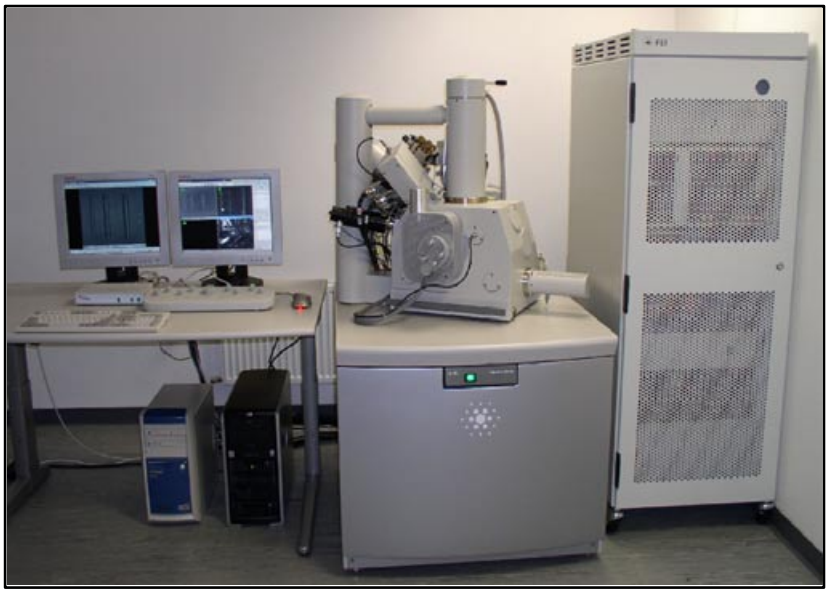
The ion system works only in the HiVac mode. In the last two application modes the column is under high vacuum, and the specimen chamber is at a high pressure (range of 0.1 to 20 Torr (10 to 2600 Pa)) of water vapour from a built-in water reservoir, or auxiliary gas which is supplied by the user, and connected to a gas inlet provided for this purpose. Observation of outgassing or highly charging materials can be made using one of these modes without the need to metal coat the sample, which is common to the HiVac mode.

Specimen exchanges take place through a chamber door which, when opened, exposes the specimen stage. Exchange time takes a few minutes. Vacuum software interlocks ensure that the system is fully protected against operating failures.

POSITIONING OF THE STAGE

A choice of computer-controlled high-accuracy five-axis stages offers precision specimen manipulation and automation of all axes for overall spatial orientation on highly repetitive or extremely irregular samples.

FIGURE 2-2 QUANTA 3D DUAL BEAM SYSTEM



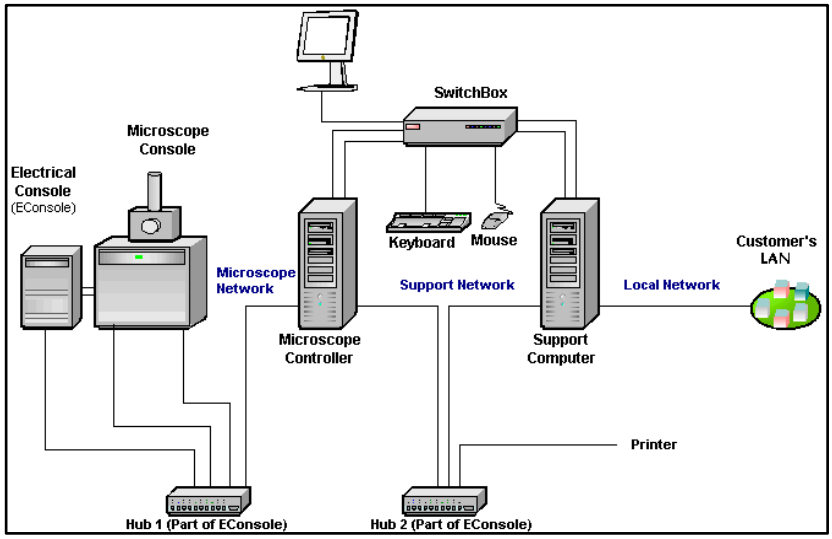
System Layout of Quanta 3D

The standard layout of the Quanta 200 3D system is based around a dedicated microscope controller along with an electrical console to power the microscope console (vacuum, gun, column, and stage).

The support computer contains various other items that are generally accepted as essentials or are dedicated to a particular application, such as forensics or failure analysis.

The user interface devices are peripherals to the microscope controller, either software or hardware. The Completion Packages differ in content depending on the demand of the application or the wishes of the customer. As a result it is not possible to specify all possible combinations here.

FIGURE 2-3 QUANTA 3D STANDARD LAYOUT SCHEME



For more information on the types of completion packages and overall content, refer to Chapter 9 ‘Options’.

SOFTWARE INTERFACE ELEMENTS

The software control consists of a shell employing application programs within a Windows 2000™ operating environment. **xT microscope Server** starts and stops the basic microscope functions and makes it possible to open and close the **xT microscope Control** software (**UI** (user interface) or sometimes **xTUI** in the dialogue boxes) which controls system functions including detection and analysis, scanning, image gathering, manipulation and output, magnification and vacuum etc. The hierarchy of user account levels consists of the following:

- FEI Account Administrator
- FEI Supervisor Users
- FEI Microscope users
- FEI Non-active Users

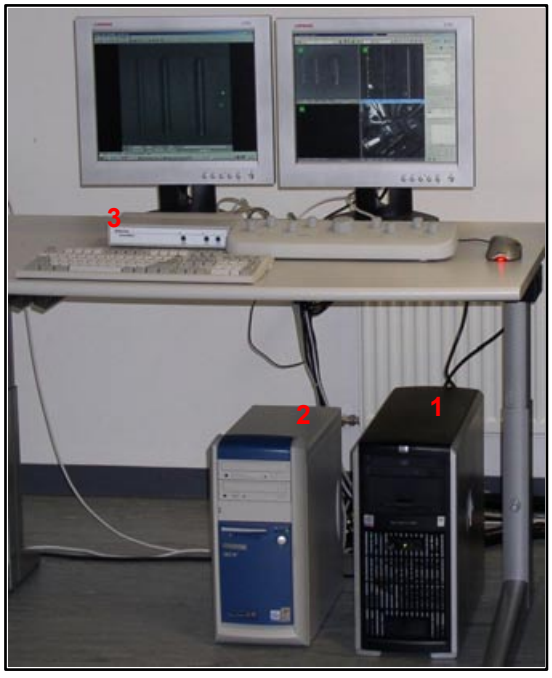
All user account levels created via **FEI User Management** software ensure for the particular users admission to both the operating system Windows 2000 and the xT microscope Control software.

See Chapters 3 and 4 for more information on Logging on and Logging off, the start-up of the system and all the features of the user interface elements.

HARDWARE INTERFACE ELEMENTS

The Quanta 3D system is computer controlled and as such has a **microscope controller** (1) which must be turned on to operate the microscope by means of the software. The power button on the microscope controller must be used to turn it on. The **support computer** (2) connects your workspace to the network and can hold some other software utilities. The **switch box** (3) switches insertions of the keyboard and the mouse to either of the two computers. The control software facilities and data are displayed graphically on the **LCD monitor** and are superimposed around and on the image (the other LCD monitor is used for optional or related programs). To control software utilities you can use **a keyboard, mouse** or the optional **Manual User Interface** (see below).

FIGURE 2-4 HARDWARE INTERFACE ELEMENTS



THE SYSTEM CONTROL PANEL

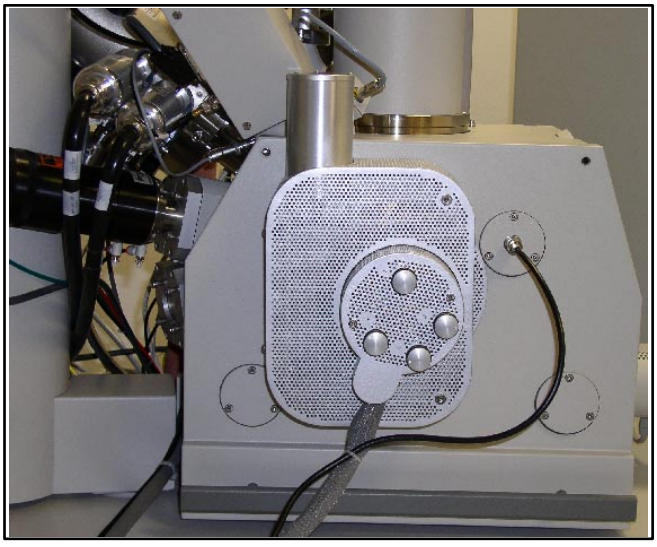
Console / System Power is activated by pressing the green **power button** on the front panel of the microscope console. This will power the sub-systems and allow interface and communication with the microscope controller. All other functions to change the status of the microscope (Standby and Shutdown / OFF conditions) are activated via software control.

FIGURE 2-5 SYSTEM CONTROL PANEL POWER BUTTON

STAGE CONTROLS

The stage is software / hardware controlled and can be oriented with reference to five axes: **X**, **Y**, **Z**, **Rotation** and **Tilt**.

FIGURE 2-6 HARDWARE STAGE CONTROLS



For detailed description of stage control procedures see Chapter 7 “stages”.

INFRARED CCD CAMERA

An optical image obtained with this IR camera assists in overall sample orientation. It also aids in positioning gas injectors on packaged IC parts or other non-uniform samples.

MANUAL USER INTERFACE (MUI)

The optional Manual User Interface provides knobs to perform functions that can also be performed with the software.

FIGURE 2-7 MUI

The MUI offers additional flexibility for controlling magnification, beam shift, focus, stigmation, contrast and brightness.

Equivalent software controls

TABLE 2-1 MUI SOFTWARE EQUIVALENTS

MUI	Software Equivalent
Image	Contrast and brightness adjusters on pages, or auto contrast and brightness icon button on toolbar
Stigmator	Shift + right mouse button
Magnification	+/- keys on numeric keypad Shift + mouse wheel for fine control Ctrl + mouse wheel for coarse control
Shift	Ctrl + left mouse button
Focus	Right mouse button

QUANTA 3D OPTIONS

A range of hardware and software are available as options for Quanta 3D workstations. This range will be extended when new items become available. Some of the options are:

- **Gas injectors:**
  for material deposition (W, Pt, C)
  for enhanced etching
- **Detectors:**
  SSBSED: two segment solid-state-back-scattered electron detector. Allows imaging in Z contrast and topographical mode
  STEM 1[*)]**:** solid state transmitted electron detector
  GBSD: combined gaseous back-scattered and secondary electron detector for ESEM mode
  2nd CCD Camera: additional infrared camera for *in situ* inspection of sample, GIS and detector positions
- FIB Software Options:
  Auto Slice & View: software package for automatic sample slicing and recording of the crossections. Prepares data for 3D reconstruction software
  AutoFIB[*)]**:** general tool for creating, editing and running scripts.
  AutoTEM[*)]**:** special script running on Auto FIB for automatic TEM sample preparation
- **Specimen Holder Kit:** accessories for multiple sample mounting
- **EDX Software Options:** software interface for third party EDX producers
- **Image Analysis:** software for image archiving, processing and analysis
- **Peltier stage:** substage for sample cooling
- **Heating stage:** substage for sample heating
- **3D reconstruction software*:** generates and visualizes 3D data from images obtained using Auto Slice and View

Contact your FEI sales representative for more up-to-date information on system options.

Note:
[*)] soon to be released at the time of publication.

3 VACUUM SYSTEM

OVERVIEW

This chapter describes the Quanta 3D vacuum system:

- Vacuum status and relevant actions (Pump / Vent)
- Vacuum modes (HiVac / LowVac / ESEM)
- Quanta 3D System States
  Start up procedure generally
  Shut down procedure generally
  Emergency off (EMO)
  Power off

Hardware System

There are three main vacuum sections:

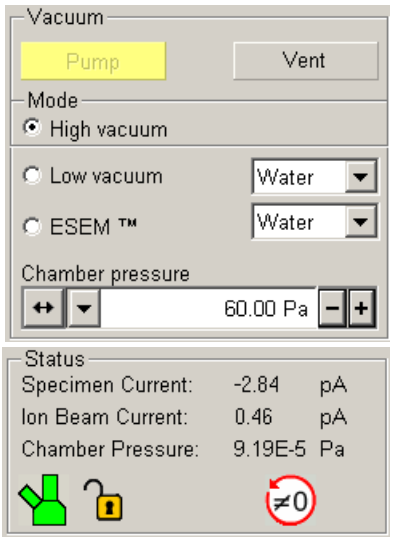
- Electron column
- Ion column
- Specimen chamber

Under operation the electron and ion columns are always pumped to high vacuum. The specimen chamber is at the pressure required for the given status (Pump / Vent) or mode (HiVac / LowVac / ESEM).

All valve and pump operations are fully automatic.

Note:
The ion beam can only be operated in HiVac. When LowVac or ESEM mode is chosen, the ion column CIV is closed.

Vacuum Statuses



The vacuum status controls are in the **Vacuum / Mode** module, located at the top of the **Beam Control** and **Temperature Control** pages. The **Pump** button controls pumping for the chamber vacuum and the **Vent** button controls venting for a sample or detector exchange.

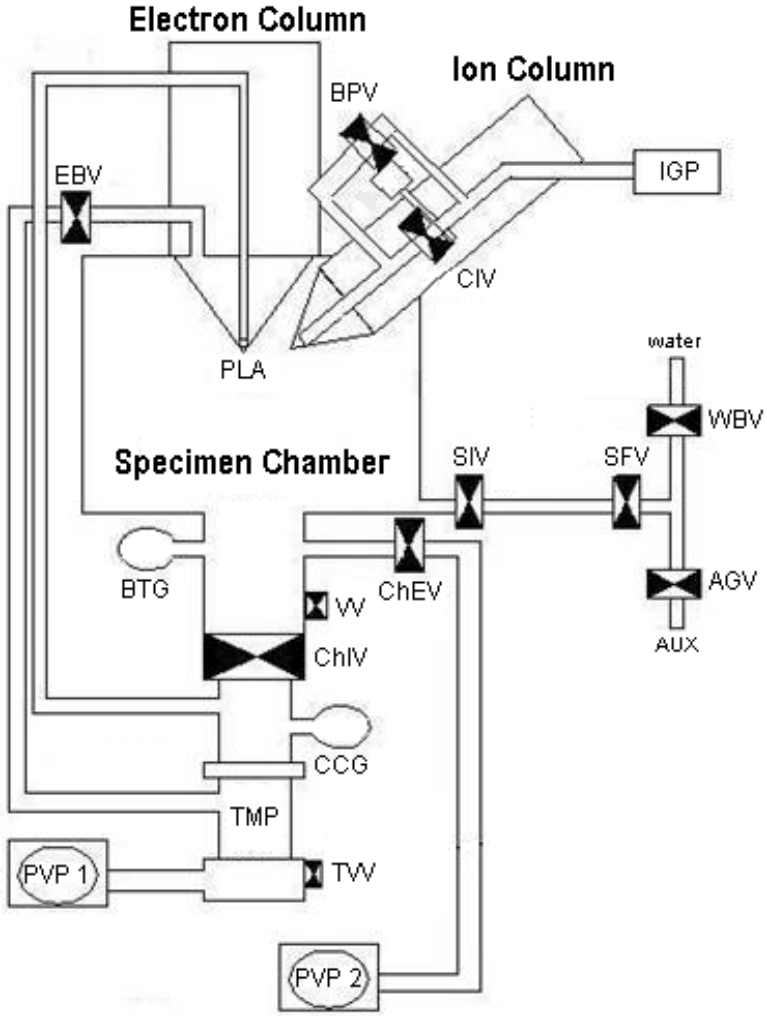
In the **Status** module at the bottom of any page the actual vacuum status is displayed with the coloured icon. This icon represents three vacuum sections schematically, each of which may have three possible colours with the following meaning:

- **Green: PUMPED**
  to the desired vacuum mode (HiVac, LowVac or ESEM)
- **Yellow: TRANSITION**
  between two vacuum statuses (pumping, venting or purging)
- **Grey: VENTED**

FIGURE 3-1 THE QUANTA 3D VACUUM SYSTEM

Legend:

AGV . . . . Auxiliary Gas Valve
BPV . . . . Bypass Valve
BTG . . . . BaraTron Gauge
. . . . . (Capacitance Gauge)
CIV . . . . . Column Isolation Valve
ChEV . . . Chamber Evacuation Valve
ChIV . . . . Chamber Isolation Valve
EBV . . . . Environmental Backing Valve
IGP . . . . . Ion Getter Pump
PLA . . . . Pressure Limiting Aperture
PVP . . . . Pre Vacuum Pump
SIV . . . . . Servo Isolation Valve
SFV . . . . . Servo Flow Valve
TMP . . . . Turbo Molecular Pump
TVV . . . . . Turbo Venting Valve
VV . . . . . Venting Valve
WBV . . . . Water Bottle Valve



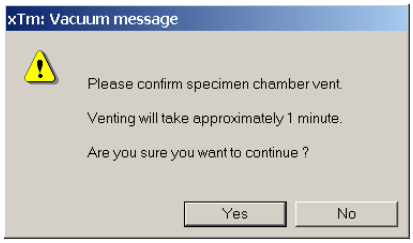
PUMP BUTTON

When the **Pump** button is pressed and the status is **Vented,** or when changing vacuum mode, the target pressure that the system will pump to will depend on the target vacuum mode. The Pump button is pressed in and not accessible.

For HiVac the system will achieve the best vacuum (lowest pressure) possible. For LowVac and ESEM, it will go to the pressure specified in the **Pressure** text box at the bottom of the **Mode** area. For the LowVac and ESEM modes, the purge function can be defined in **Preferences / ESEM / Purge.** When finished, the **Vacuum Status** in the **Status** module should indicate **Pumped** (green icon).

If the **Pump** button is selected when only **venting**, the venting procedure stops and the system immediately starts to pump to the target vacuum pressure.

VENT BUTTON


xTm: Vacuum message
Please confirm specimen chamber vent.
Venting will take approximately 1 minute.
Are you sure you want to continue ?
Yes
No

When the **Vent** button is selected and the system is in any **Vacuum** status, the confirmation dialogue appears. After confirmation the system gently switches off the detectors, high voltage supplies, and pumps and uses the appropriate valves to vent the system.

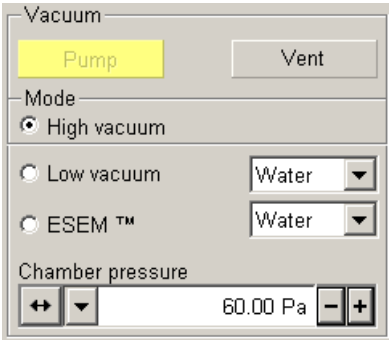
The Vent button is pressed in and not accessible. After a specified venting time the venting valve will close and the **Vacuum Status** in the **Status** module should indicate **Vented**. The button will pop out again.

If the **Vent** button is selected when only **pumping**, the dialogue appears. After confirmation the pumping procedure stops and the venting procedure starts.

When the **Vent** button is selected when **Vented** status has already been reached, the dialogue appears. After confirmation the venting valves re-open. After the specified venting time, the valves will close.

Note:
If you vent the system in order to change a detector, wait until the icon with a greyed specimen chamber appears in the **Status** module. Otherwise there is a risk of a detector assessment malfunction, and as a result the PLA (see below) will not be known by the system.

Vacuum Modes



Three radio buttons are used to select the target operating mode that the instrument will be placed in when a **Pump** sequence is initiated. The vacuum system recognizes **High Vacuum**, **Low Vacuum** and **ESEM** modes. All of these modes are operative at the user level, to allow the user to be precise about the detector configuration installed in the chamber.

HIGH VACUUM

This is the conventional operating mode associated with all scanning electron microscopes. The high vacuum condition is common throughout the column and specimen chamber. The **ETD** or any optional HiVac detectors can be used, but no gaseous detectors will operate.

LOW VACUUM AND ESEM MODES

In either of these modes, the column sections are under higher vacuum than the specimen chamber, where pressure ranges from 0.08 to 20 Torr (10 to 2670 Pa).

Which of these is used depends on the detector installed. The Low Vacuum mode is meant to be used with the **Large Field Detector (LFD)**. The ESEM mode is meant to be used with the **GSED** or **GBSD**. The system automatically detects the gaseous detector and offers a relevant mode in the **Vacuum / Mode** module.

When **Low Vacuum** / **ESEM** mode is entered from **ESEM** / **Low Vacuum** mode by selecting an appropriate mode radio button, nothing will happen unless there is a different gas type being used for the two modes. In this case, the appropriate gas type will be selected.

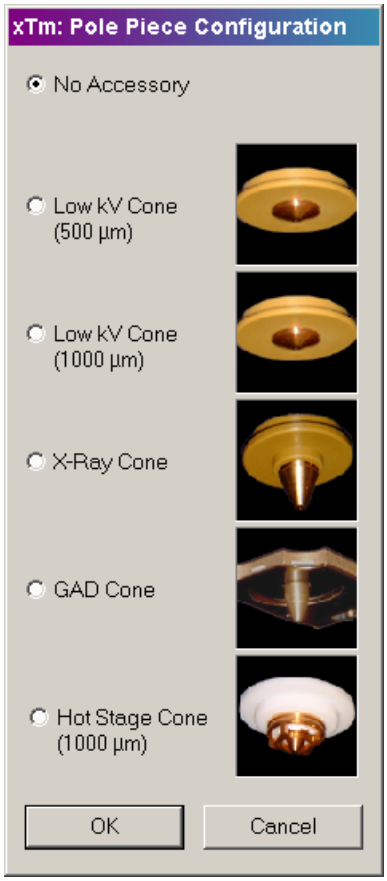
When **Low Vacuum** / **ESEM** mode is entered from **High Vacuum** mode by selecting an appropriate mode radio button, the system prompts the user with the **Pole Piece Configuration** as a graphical dialogue. This happens only for the first time after a particular vent procedure.

Pressure

The **Pressure** adjuster is used to set and display the target chamber pressure. Torr, Pascal or Millibar are available, and can be selected in **Preferences... / Units** (see the end of Chapter 5).

When the system is in LowVac or ESEM mode, and the pressure value is changed in the Pressure adjuster, the pressure will automatically start changing to the new value. When the system is in any other status besides Vacuum - LowVac or ESEM, and the Pressure adjuster is changed, the new value will be used as the target pressure when the system pumps to a Low Vacuum or ESEM mode.

The actual specimen chamber pressure is displayed in the **Chamber Pressure** field of the Status module at the bottom of all pages.



Pressure, the PLA and Cones

The maximum allowed pressure in LowVac or ESEM mode is determined by the size of the **PLA** (Pressure Limiting Apperture) and the gas type. If the PLA is incorporated in the detector, due to the contact connector, the system will determine the installed detector type, thereby knowing the size of the PLA and setting the **Pressure** adjuster range accordingly. In all other cases the **Pole Piece Configuration** dialogue appears for the user to select the appropriate configuration.

This pressure will be the same for the LowVac and ESEM modes. From that point on, this information will automatically be used until the system is vented again.

The PLA can only be changed when the system is in Vented status. For that reason the vacuum system sets the PLA to *unknown* whenever the system is vented. When pumping to HiVac mode the PLA size is not critical and need not be known. However, when pumping to LowVac or ESEM mode, or when switching to either of these from pumped or pumping HiVac mode, the PLA must be known. Along with the gas type, this information sets pressure limits and rates for vacuum level changes. The **Pole Piece Configuration** dialogue prompts the user to inform the system about the PLA in use.

Clicking on the **OK** button selects the default 'No Accessory'. Clicking on any other option cone will inform the system that the respective cone is installed and after OK is clicked the PLA size is known. Clicking on **Cancel** will revert the system back to its initial operating mode (HiVac or Vent).

Pressure and Working Distance

- **ESEM**

  It is assumed that the GSED or GBSD are installed and the sample is visible in the image display area.

  For **standard imaging** choose the highest specimen point and bring it to the 15 mm Working Distance (the yellow line in the Optical Beam Quad). Focus the image and then click on the Z to FWD icon button on the toolbar.

  Adjust chamber pressure to achieve the brightest possible image. Lower the pressure 0.5 Torr (67 Pa) from this point. This should place the pressure in the appropriate range on the curve in the following figure.

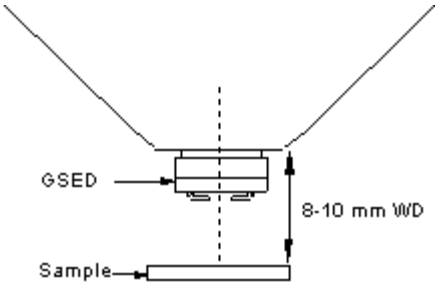
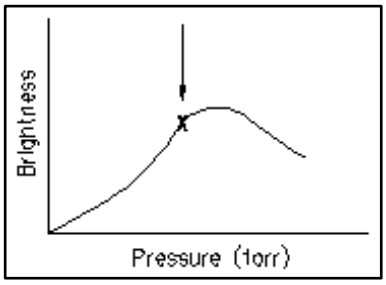
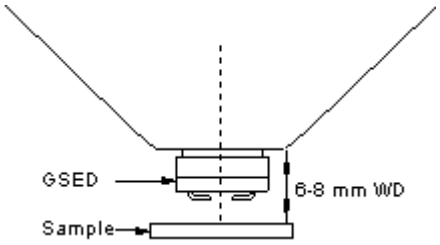


FIGURE 3-2 BRIGHTNESS VS PRESSURE



Adjust contrast and brightness to personal taste to obtain a clear image. An image which is optimized should allow small changes (approximately 0.5 mm) in working distance without the need to alter chamber pressure.



- **ESEM and LowVac**

  Higher resolution imaging is achieved by moving the sample closer to the pole piece; the final lens performs better when the sample is at about 6–8 mm working distance (1–3 mm from the GSED, GBSD or 2–4 mm from the Pole Piece (LFD) or BSE (LFD)). At this closer distance, the chamber pressure will need to be higher.

  Some experimentation may be necessary, as the relationship between working distance and chamber pressure is largely sample-dependent.

Note:
Always use the CCD image when adjusting the height of a sample. It is advisible to do this by the center mouse button control in the Optical Beam Quad.

Using Gas

ESEM and Low Vacuum modes allow the user to image samples in a gaseous atmosphere, which can be selected in the **Mode** drop down box:

- water vapour from a built-in water reservoir,
- auxiliary gas which is supplied by the user, and connected to a gas inlet provided for this purpose.

Auxiliary gas requires a regulator on the gas cylinder to provide a pressure of about 100 kPa.

Purge

This is a procedure in which the specimen chamber is flooded several times with the selected gas to replace the current chamber gas with a new gas determined by the target operating mode. This is applied when the system is:

- just turned to Low Vacuum / ESEM mode from vented status,
- the system is in Low Vacuum / ESEM mode and the the gas type is changed,
- the system is in Low Vacuum / ESEM mode and the Purge button is pressed.

Generally speaking, this process involves pumping down the chamber to a low value to remove the old gas, then “flooding” the chamber with the new gas to the desired pressure until the old gas is removed and the chamber is mostly filled with the new gas.

This function includes options for setting up, initiating and terminating the chamber purging operations. The setup and detailed description is found in the **Preferences... / ESEM** tab.

Note:
This procedure can take several minutes, depending on the Preferences setting. Wait until Vacuum status indicates **Vacuum**, because detectors do not start operation until vacuum is reached.

See Setting **Preferences... / ESEM** tab at the end of Chapter 5 “Operations” for more details.

Vent Water Bottle

On occasion the water reservoir needs to be filled. To do this, see Refilling the Water Bottle in the Chapter 8 “Maintenance”.

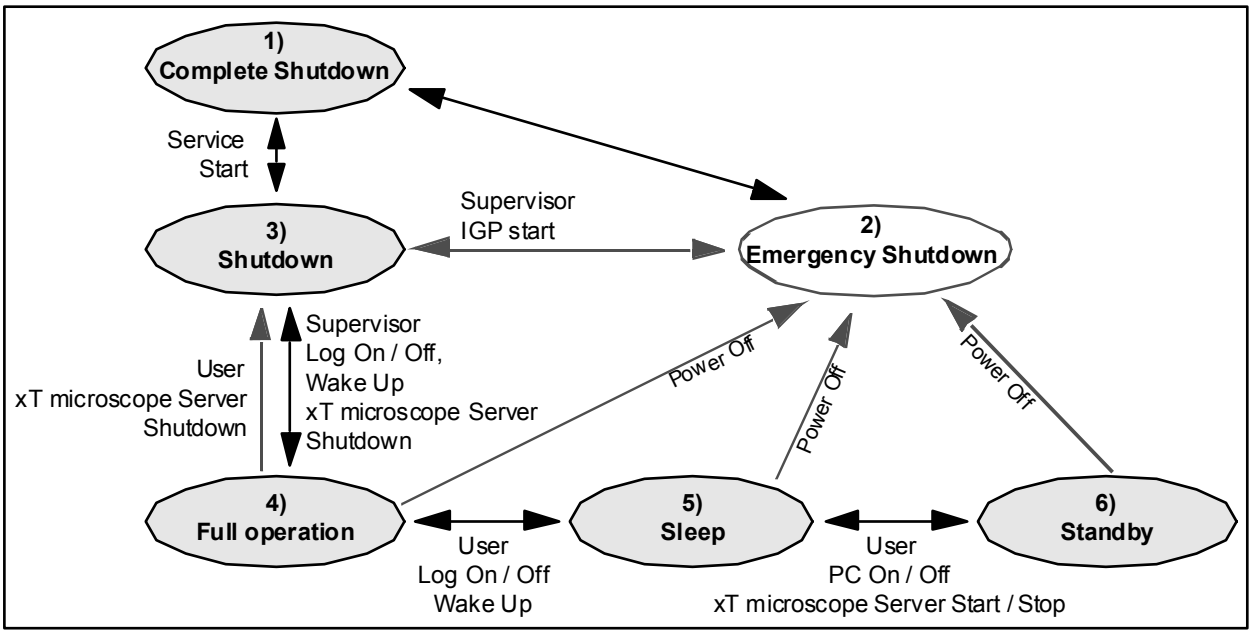
Quanta 3D System States

There are several system states listed in the following table and in the tree. The transitions among them depend on their initial and final conditions and are accessible from a particular user account.

TABLE 3-1 DESCRIPTION OF QUANTA 3D STATES

State	When to Use	Switched off components	Steps to Return to Full Operation
1. Complete Shutdown	During transportation or service actions	System Vacuum (including IGP), Emitter(s), Electronics and Computer(s)	Service Start Supervisor Log On Supervisor Emitter On User High Voltage On
2. Emergency Shutdown	During power failure	same as 1)	same as 1) from emergency shutdown Supervisor IGP Start
3. Shutdown	When not using the system for more than 10 days.	System vacuum (except IGP), Emitter(s), Electronics and Computer(s)	Supervisor Log On Supervisor Emitter On User High Voltage On
4. Full Operation	Working	–	–
5. Sleep	When not using the system overnight.	High Voltage, LMIS, GIS Heaters	Wake Up
6. Standby	When not using the system for more than 2 days.	High Voltage, LMIS, PC + monitor	PC On, User Log On, Wake Up

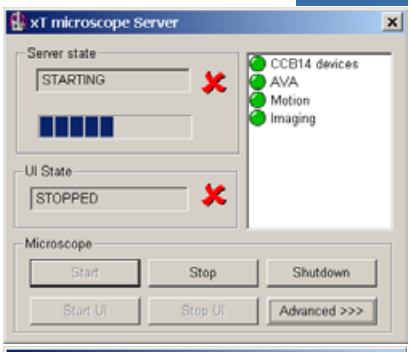
FIGURE 3-3 QUANTA 3D STATES TREE

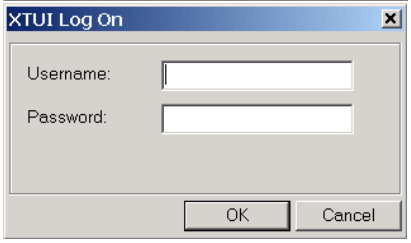


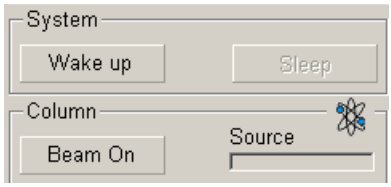
STARTUP PROCEDURE GENERALLY

TABLE 3-2 STARTUP PROCEDURES GENERALLY

System State	Action
0. Complete / Emergency Shutdown	Before starting the system, check for the presence of electrical power, compressed air, and nitrogen for venting and cooling. With the exception of nitrogen, interlocks prevent the vacuum system from operating if any of these are not present. For the following steps we assume the powered microscope with IGP pump running.
1. Standby	Push the **power** button found on the front control panel of the microscope.
2.	Switch on the PC. The operating system [a] Window 2000 loads and displays the appropriate icons on the monitor desktop.
3.	Click on the **xT microscope Server** icon to start the software. Wait until its dialogue is fully functional (All LEDs needs to be green). Click on the **Start** button.
4. Sleep	Click on the **Start UI** button to start the **xT microscope Control** software. The main window appears behind the **XTUI Log On** dialogue. Enter your **Username** and **Password**.
Note:	If the IGP is not running go to alignment page **100 - ION: Source control** (see Chapter 6 "Alignments") and start the IGP.
5. Full Operation	Click the **Beam On** button of the electron beam when operating electron beam only or [b] **Wake Up** button to start ion beam also. The system automatically switches on the appropriate beams (this is indicated by an increase in the **Source** progress bar in the column module when the ion beam is selected), starts the LMIS and heats the GISes.
6.	Select a quad, a detector, a beam and beam parameters. Switch on the beam and unpause the quad.







Note:

[a] Once you have your **FEI Microscope user** (or **Supervisor**) **account** set up via **FEI User management** software by **FEI Account Administrator** (see Chapter 4 "User Interface"), you can use your name and password to access both Windows 2000 system and the **xT microscope Server** and **Control** software. (Take note of the case sensitive passwords necessary at Win 2000 and xT microscope Control server Log On points. A password is advisable for logging on to protect individual settings and results.)

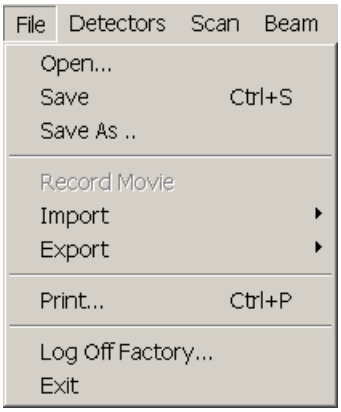
[b] Usually, the Quanta 3D remains on with the vacuum system in operation, but typically both (electron and ion) emitters and High Voltage for both columns remain off. The system starts with the setting in use when the **xT microscope Control** software was closed. This

allows quick resumption of daily operation without having to start the system from any Shutdown state.

SHUTDOWN PROCEDURE GENERALLY

TABLE 3-3 SHUT DOWN PROCEDURES GENERALLY

System State	Action
1. Full Operation	Click the **Sleep** button to switch off both beams and stop the ion source.
2.	Select **Tilt 0°** (Ctrl + E) in the stage menu. Click the **Vent** button to vent the chamber, remove your [c] sample if needed and remove the Peltier Cooling stage if installed.
3.	Click the **Pump** button to pump to High Vacuum.
4. Sleep State	Select [a] **Log Off** in the **File** menu to log Off the present user and provide the **Log On** dialogue for entering another user. Switch off the monitors.
5. Standby [b]	Click the **Stop** button to stop the **xT microscope Server** software. Switch Off the both PCs and the monitors.
5. Shutdown[b]	Click the **Shutdown** button to shutdown the **xT microscope Server** software and to switch Off the both PCs and the monitors.
6. Complete Shutdown[d]	Disconnect all power supplies, inputs and outputs. Switch off the nitrogen inlet if used.



Note:

[a] Waiting for a new user leaves the status of the **xT microscope Control** software non-operational and only the **xT microscope Server** software is active. Therefore changing the user does not require Loggin off / Logging on at Windows 2000 level, but just restarting the UI level.

[b] The power plug should not be disconnected. The system can be left in this state if electrical power is supplied to the instrument because the IGP is running and pumping the ion column.

[c] It is strongly suggested to always leave the chamber in HiVac mode when not being used. When the sample chamber is left in the LowVac / ESEM mode when the microscope is not being used, water vapour is likely to accumulate in it and the water reservoir or gas cylinder empties prematurely.

[d] Complete shutdown should be performed only if absolutely necessary and for the shortest possible time, so as to recover the column vacuum without the necessity of a system pump. Normally, you would only perform a complete shutdown for transportation of the system or for service actions, like repair to essential systems such as electrical and air supplies.
The shutdown procedure brings the system to the non-powered state, where the vacuum in the Ion column area is no longer supported by running pumps and IGP. All valves are closed, and the electron column and specimen chamber areas are vented.
This procedure should only be carried out by a Supervisor.

EMERGENCY OFF (EMO)

An emergency off is similar to that which would happen after a MAINS power off while the instrument is completely operational.

In case of emergency it can be handled by the system. Strike one of the large yellow and red EMERGENCY buttons (if available) to switch off the electrical power completely. If there is no one present, proceed to press the breaker switch in the hole at the back of the Electronics Cabinet. This breaker switch is inside the top-back cabinet cover opening. If this is not easily accessible turn off the mains wall switch (if present), and disconnect the mains plug from the mains socket.

Note:
The EMO switches are latching. Once pushed in, they must be rotated in the direction of the arrows to reset.

FIGURE 3-4 MAIN SWITCH OFF

Power Off

Take sufficient measures to avoid power failures as much as possible. If a power failure occurs during normal operation of the system, it comes down to a safe state and the following happens:

- The HV is switched off abruptly. The cooling process is similar to that of a normal shutdown procedure.
- The Ion column isolating valve closes so the high vacuum in the column chamber is not completely lost.
- The specimen chamber vents gently, automatically.
- The momentary adjustments of all the system parameters (high voltage, magnification, stage positions) are lost if they were not saved.

C a u t i o n !

A trained FEI Service Engineer or Authorized Supervisor must restart the system after an emergency power off (see 100 - ION: Source Control in the Chapter 6 “Alignments”).

4 SOFTWARE CONTROL

OVERVIEW

This chapter gives an overview of the **xT microscope Control** (referred to ass **UI** or sometimes **xTUI** in dialogue boxes), **xT microscope Server** and **FEI User management** software, and describes the functionality of each part of the user interface. It takes you from the first main window and menu bar through each item on the pull-down menus. Graphics illustrating most of the choices help you locate specific features.

The software interface controls most system functions, including imaging, image and movie gathering / manipulation / output, detection and analysis, stage and vacuum control.

OTHER SOFTWARE AND HARDWARE

Call Customer Service for advice before installing software or hardware that is not required for system operation. Other software, such as screen savers or hardware network cards may corrupt the xT microscope Server / Control software under some circumstances and may invalidate warranty.

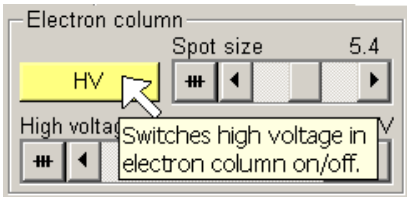
For more detailed information about Windows 2000, refer to the *Microsoft® Windows™ User's Guide* shipped with your system.

Software Interface Elements

ICONS

are small symbols indicating a specific software application. Double-click on the icon to activate the program.

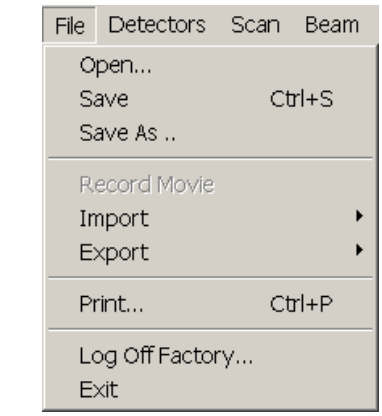
There are also **functional icons** in the toolbar for selecting some software functions quickly. Clicking on any of these will cause them to press in, and when deactivated by clicking again they spring out. There are also some **informational icons** in the status field, for instance, that indicate some particular system status.

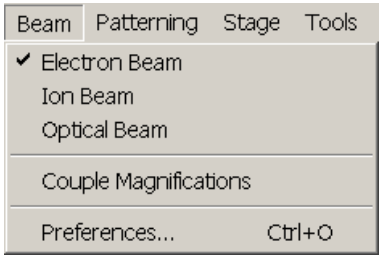


Tool-Tips

are activated when the cursor is left over an item on the user interface for more than two seconds. A short explanation of the item will appear until the cursor is moved away from the item.

PULL-DOWN MENUS





The microscope uses menu-oriented software; you perform functions by choosing items from the **Menu bar**. The Menu bar selections contain pull-down menus that display grouped listings of available commands or settings. Some menu items are shown in grey and cannot be selected. You might also get a beeping sound if you try to select unavailable functions.

Pull-down menu selections followed by ellipsis (…) indicate, that a dialogue box will display (the same behaviour occurs when the selection is a command). Selections with a right arrow indicate that an additional submenu of choices will display. If a selection is a parameter value, the new value is updated immediately and a check mark appears in the pull-down menu.

Using the Mouse

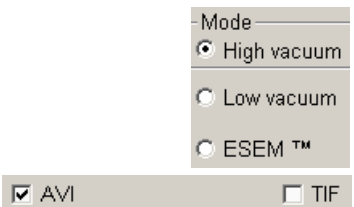
Click on the menu item in the Menu bar, then drag the cursor down to the desired selection and release the left mouse button.

Using the Keyboard

Press ALT plus the underlined letter (for example, **ALT + F** for the File menu), and then select from the choices with the left mouse button or with the up / down (left / right for submenus) arrow keys.

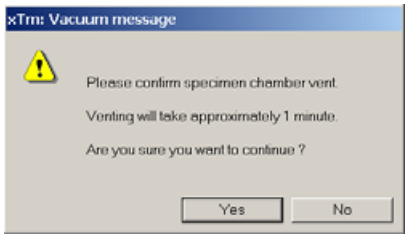
Some often-used commands can be quickly activated by hot keys (a combination of simultaneously pressed keys) at any time. This possibility is given by a particular button combination on the right side of the pull-down menu adjacent to the appropriate command.

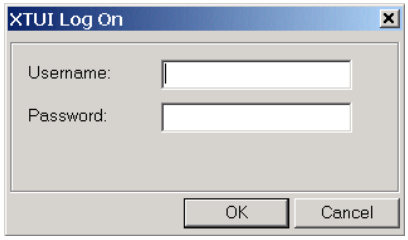
RADIO / CHECK BUTTONS



Within a group of related **round Radio buttons**, only one selection can be made active at any time by clicking in the individual box.

A single one or a group of **square Check buttons** can be switched on (checked) / Off (empty) by clicking in the individual boxes.

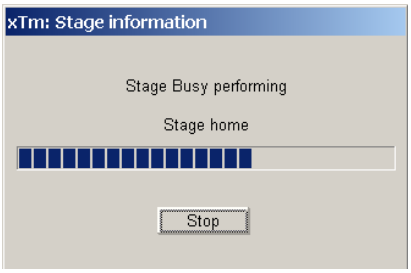

xTm: Vacuum message
Please confirm specimen chamber vent
Venting will take approximately 1 minute.
Are you sure you want to continue ?
Yes
No



DIALOGUES

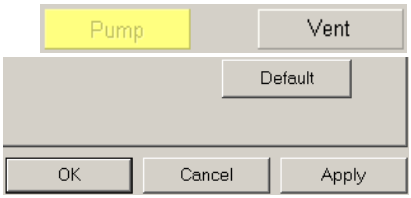
appear when the system needs more information from you before it can carry out a command. Some **Dialogue boxes** do not let you access other functions until you exit the box. Other dialogue boxes let you perform other tasks while they remain onscreen and active. For example, the Preferences dialogue boxes can remain open while you do other tasks.

You can input information using radio / check buttons, command buttons and **Text boxes** (direct keyboard input is used to produce text such as labels, passwords and specified values of certain parameters).



Progress boxes indicate progress of a procedure over time by means of a progress bar.

COMMAND BUTTONS

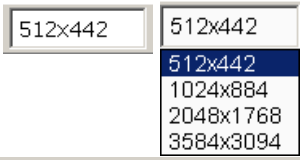


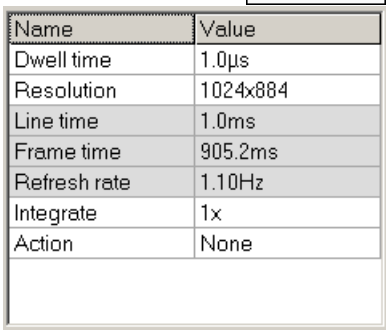
carry out or cancel functions. They press in when clicked and some change colour to show activity. When reversing the function the button springs out.

Command buttons have labels that describe the actions performed by clicking on them. The mostly commonly used ones and their usual functions are:

- **OK** button closes the dialogue box and updates all information shown in the dialogue box.
- **Cancel** button quits the dialogue box without updating the information.
- **Apply** button introduces the change immediately and remains in a dialog box for further setting.
- **Reset** (or **Default**) button restores previous (or default) conditions and leaves a dialog box.

LIST BOXES





Name	Value
Dwell time	1.0µs
Resolution	1024x884
Line time	1.0ms
Frame time	905.2ms
Refresh rate	1.10Hz
Integrate	1x
Action	None

contain available choices, such as screen resolution, magnification settings, etc. Click on it to roll down the selection list of all available values.

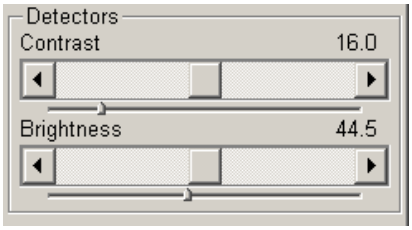
Property Editors represents group of values, which can be saved as one preset. The entry space is white and the prohibited zones are shaded. The user should click in the **Value** side of the relevant **Name** of the property editor and then either type in the new value or select it from the drop down list.

CONTROL ADJUSTERS

Ramp adjusters

allow you to change parameters, such as voltage, in an incremental way by clicking and dragging the end adjuster to the right. Dragging the slider to the left reverses the function to its least value.

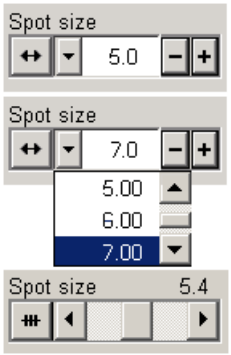
Continuous adjusters



allow you to change parameters, such as contrast, brightness and scan rotation, in a continuous way by clicking and dragging the middle adjuster or clicking in the grey bar. They always have labels in the upper left and right corners for readout information.

- **Middle adjuster** – for large or small adjustments.
  Its behaviour depends on where you release it – the further from center the middle adjuster is pulled, the larger the change. Unlike a scroll bar, the middle adjuster always snaps back to the center of the adjuster. Logarithmic response allows coarse control with larger movements.
- **Grey bar** – for larger adjustments, single step increments
- **End arrow** – for finer adjustments, single step increments
- **Small adjuster** – for Linear adjustment, continuous response

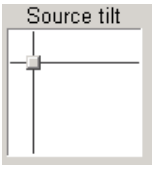
Preset / Continuous adjusters



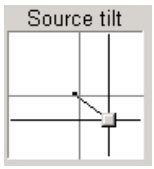
are used for values that have both a continuous range and a list of presets to achieve total control over one function. Items on the slider / drop-down change according to the function chosen. The button on the left side of the adjuster toggles between modes:

- **Drop-down list:**
  clicking on the -/+ buttons on the right of the drop-down menu steps through the values Up / Down in the list (given in the Preferences for that particular parameter), but only shows one value at any time in the text area. Clicking on the down-arrow next to the toggle button causes the drop-down list to appear. If the list extends further than is visible, a scroll adjuster appears on the right side of the list. Clicking on a value in the list highlights that value and enters it as current value in the text area displayed at the top.
- **Adjuster mechanism:**
  The adjuster has fine control of the values, see above.

TWO-DIMENSIONAL X-Y CONTROLS



✓ Absolute



Absolute
(really Relative)

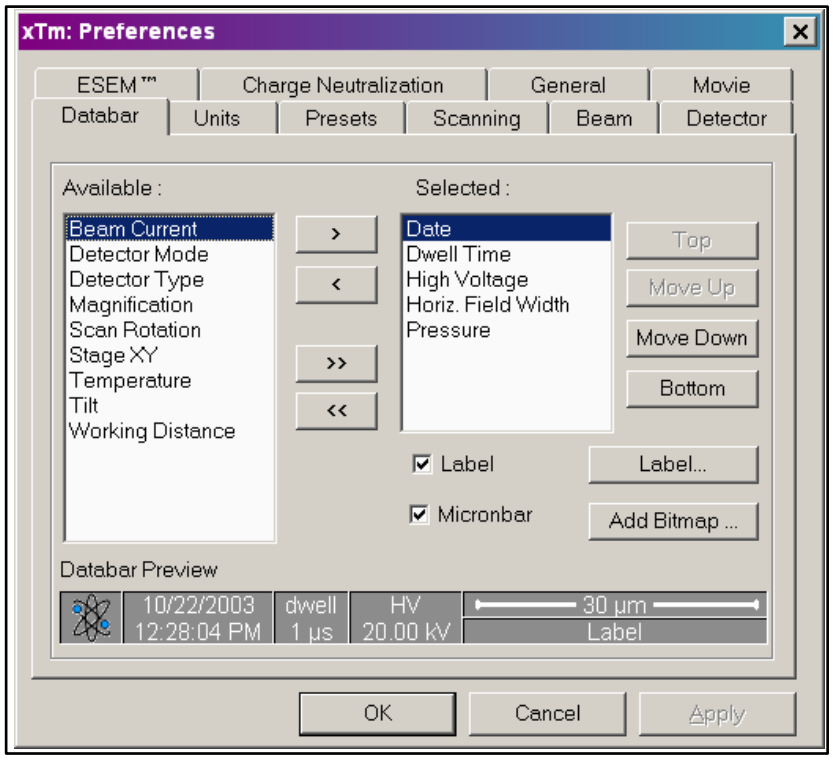
are represented by an X-Y box. The position of the crosshair is related to the actual settings and to the full range of the parameters being represented by the perimeter of the box.

Click and hold down the left mouse button in the grid to display a crosshair in the image area. The cursor changes to a 4 axis cross and can be moved in four directions that correspond to the X, Y screen values. To fix the values, release the mouse button and the position of the crosshair is updated.The sensitivity of the X-Y control can depend on the magnification chosen. At higher magnification, you may click on the center square with the right mouse button to open a dialogue showing a choice of **Zero / Absolute (ticked / unticked)**. **Zero** brings the 2D control to the center. **Absolute** (ticked) gives a linear movement and **Absolute** (unticked) gives a Logarithmic response for high sensitivity at higher magnification.

TABBED DIALOGUES

form either across the operating page or in a quad (lower right). These can be alternately opened by clicking on the label tab along the top of the dialogue area. Preferences and other conditions can be changed and stored in these dialogues.

FIGURE 4-1 PREFERENCES TABS

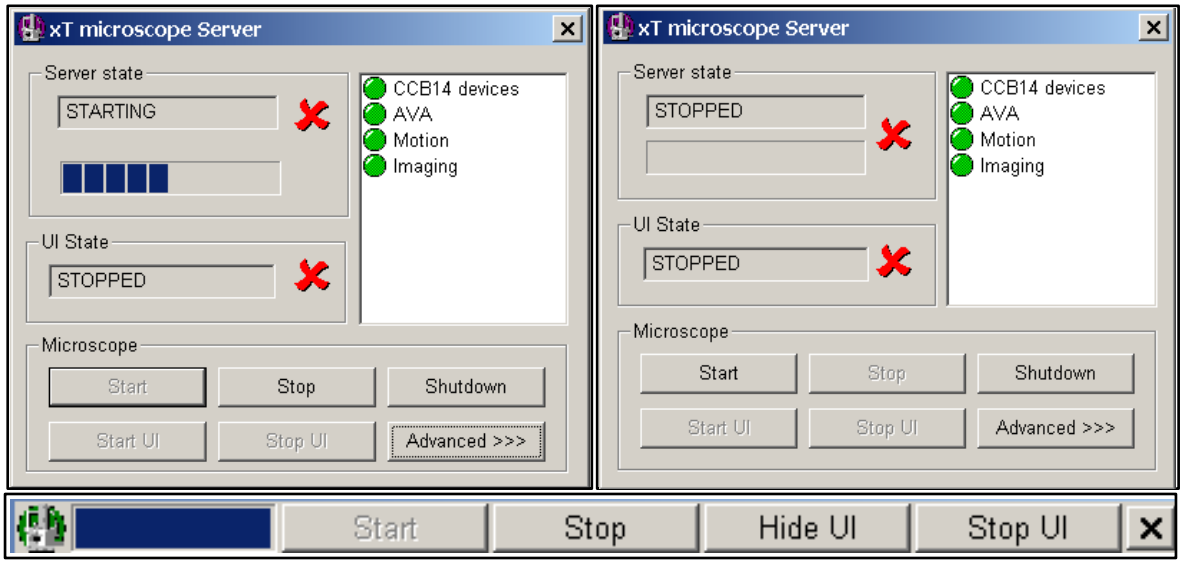


xT microscope Server Software

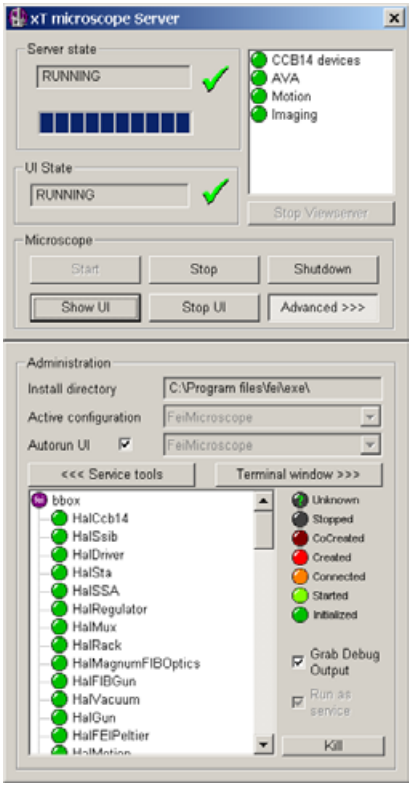
The **xT microscope Server** Software starts and stops the basic microscope functions and makes it possible to open and close the **xT microscope Control** software.

Double-click on the icon found on the Windows desktop. The main **xT microscope Server** window appears. Once it is established, clicking with the right mouse button on the title bar opens a dialog that offers the option to minimize the server to the top bar of the UI.

FIGURE 4-2 XT MICROSCOPE SERVER WINDOW



Server State / UI State modules



displays the **RUNNING** or **STOPPED** state of the xT microscope Server services (**Server State**) and of the xT microscope Control software (**UI State**). During a transition between these states **STARTING** or **STOPPING** is displayed.

Microscope module

Here you can find six buttons controling individual features:

- **Start / Stop** buttons starts / stops xT microscope Server services.
- **Start UI / Stop UI** buttons opens / closes xT microscope Control software (UI).
- **Shutdown** button shuts down xT microscope Server software in three steps:

  1) same as **Stop UI** button

  2) same as **Stop** button

  3) switches power off (reverse procedure to pushing **power** button found on the front control panel of the microscope)

Advanced button

displays detailed settings and operational conditions used for accurately specifying the software operation / hardware function state when calling the service.

xT microscope Control Software

The following elements make up the **xT microscope Control** (see Figure 4-3 for numbering):

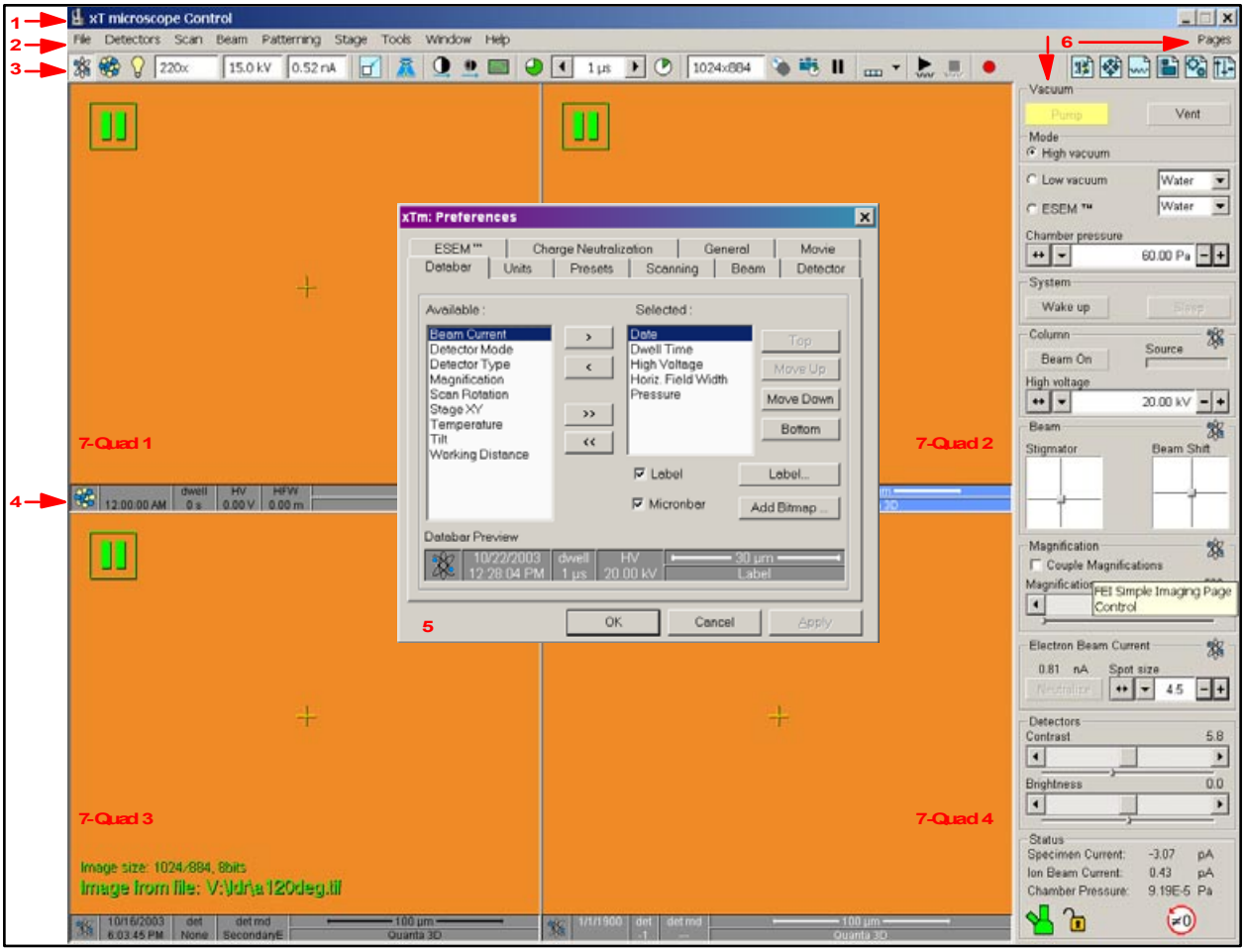
1. **The Title Bar** – labels the application
2. **The Menu Bar**– contains all operation menus and submenus
3. **The Toolbar** – contains all iconised button functions
4. **The Data Bars** – contains all data information entered by preference for storage/printout of the image
5. **The Preferences dialogue** – presetting of operating conditions (call out window)
6. **Pages and Modules**– contains all pages made up of more modules
7. **Quad Image Windows** – 4 image windows mode providing independent image functionality modes

   The Main Image Window – single window image mode (not displayed)

THE MAIN WINDOW

displays status and control features for the **xT microscope Control** (xTUI or UI), including the image window, application bar, menu bar, toolbar, data bar and pages.

FIGURE 4-3 THE MAIN WINDOW



THE TITLE BAR

displays the application currently running.

FIGURE 4-4 THE TITLE BAR

This bar will change displayed information depending on the associated program currently running e.g. EDX, Image analysis.

THE MENU BAR

displays pull-down menus across the top of the screen below the Title Bar.

FIGURE 4-5 THE MENU BAR

The following menus are available:

TABLE 4-1 MENUS

Menu Item	Use
File	Administrative files functions
Detectors	List of detectors and custom control functions
Scan	Scan conditions for electron and ion beams
Beam	Choice of beam conditions electron / ion / optical and controls
Patterning	Patterning and deposition functions
Stage	Stage navigation and corrective functions
Tools	Image auto functions and useful items
Window	The image windows display functions
Help	About xT microscope Control software and on-line documentation

Select pull-down menus from the menu bar by pressing:

- the left mouse button on the Menu title
- ALT + underscored keyboard letters
- ALT and then use keyboard arrows

Note:
related toolbar icons are displayed to the right of the function title.

THE TOOLBAR

displayed below the Menu bar lets you select system functions by their icons. The toolbar can be different in content or arrangement depending on the system or user preferences (see **Preferences... / General** tab in Chapter 5 “Operations”). The style of the drop down list boxes (with or without arrows) can be selected in the same way.

If any icon represents the menu function, look in the following pages for a description.

FIGURE 4-6 THE TOOLBAR

Rest the cursor on the icon for two seconds without clicking on it to see its highlighted caption (tool-tip), which displays the use of the tool.

Whenever you select a function the corresponding icon is highlighted. Icons that activate an automated procedure are not highlighted.

Magnification / kV / Beam Current List box

The value ranges are different for both ion and electron beams. Clicking directly on the value box allows the list to open for selection of the Magnification / kV / Beam Current. Clicking on the required value sets it in the top window of the drop-down box and at the same time changes the column condition to that value. The default lists of values are chosen in from the **Preferences... / Presets** tab.

Pixel Resolution Per Beam

contains the Pixel Resolutions possible for viewing or recording an image (normal output is 1024 x 884). Clicking directly on the value box drops the list so that all possible resolutions can be seen. Selecting results in the immediate change of the scan resolution in the quad or full screen. Since the current dwell time remains unchanged, the actual scanning frequency changes when a new pixel resolution is selected.

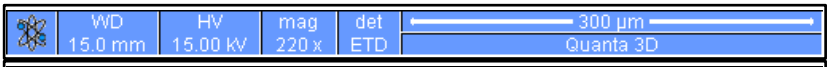
THE DATA BAR

The **Data Bar** displays Instrument, Image and labelling information. This can be a combination of kV, Detector, Spot, X and Y coordinates, for instance. They can be placed in any order and will expand or contract to fit as long there is enough room. The micron bar is above the user’s label area.

Setttings in the Data Bar can be changed in the **Preferences... / Data Bar** tab (see Chapter 5 “Options”).

FIGURE 4-7 THE DATA BAR EXAMPLES

Active Electron



Inactive Ion

Inactive Optical

Active Patterning

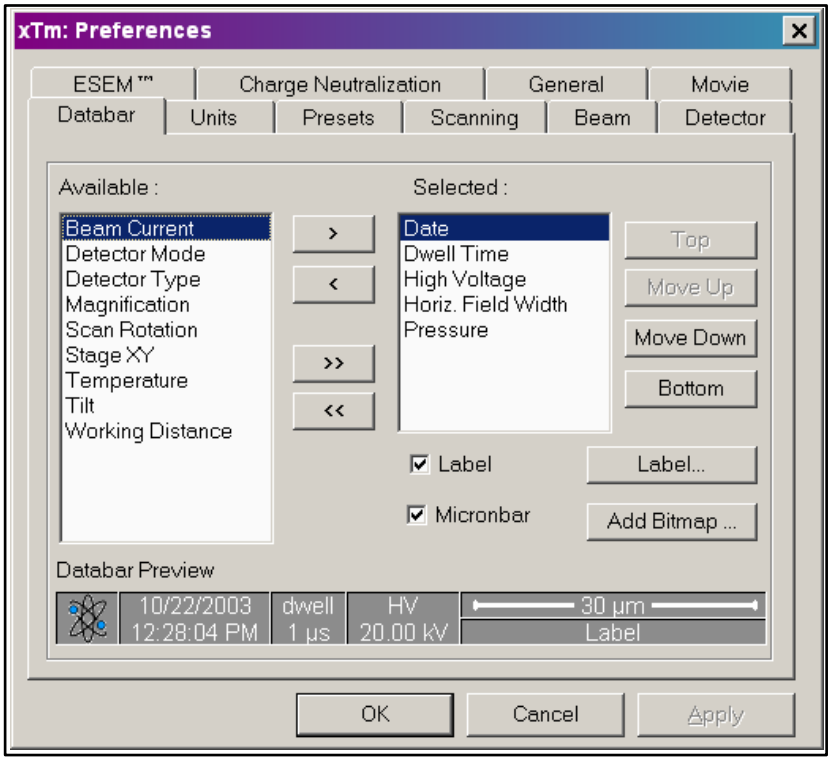
Inactive Patterning

PREFERENCES... (CTRL + O - *letter*)

can be found at the end of the pull-down menus: **Detectors, Scan, Beam, Stage** and **Tools**. (When Preferences... are opened from these menus the window opens in the appropriate tab.)

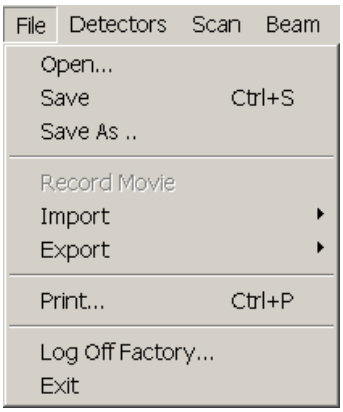
The complete preferences dialogue consists of tabbed sections for **ESEM, Charge Neutralization, General, Movie, DataBar, Units, Presets, Scanning, Beam and Detector**. Clicking on the required tab opens a section that allows changing and presetting conditions for the function chosen.

FIGURE 4-8 PREFERENCES DIALOGUE



Further information about how to make use of these preferences can be found under **Setting Preferences**... (see the end of Chapter 5 “Operations”).

The File Menu (Alt + F)

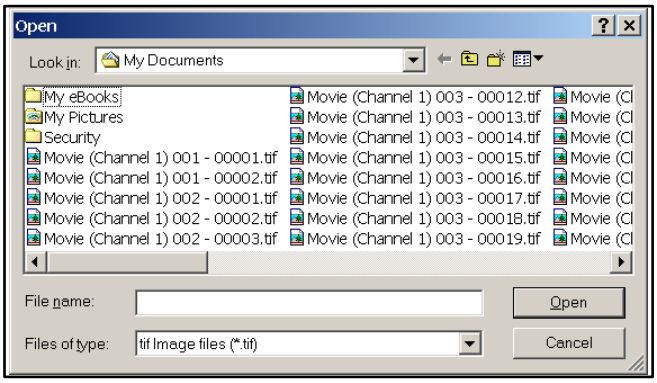


opens File menu administrative functions:

Open

opens a dialogue for opening images previously stored to the harddrive. Only file saved in **TIF** format is available to open.

FIGURE 4-9 OPEN DIALOGUE

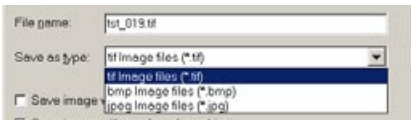

Open
Look in:
My Documents
My eBooks
My Pictures
Security
Movie (Channel 1) 001 - 00001.tif
Movie (Channel 1) 001 - 00002.tif
Movie (Channel 1) 002 - 00001.tif
Movie (Channel 1) 002 - 00002.tif
Movie (Channel 1) 002 - 00003.tif
Movie (Channel 1) 003 - 00012.tif
Movie (Channel 1) 003 - 00013.tif
Movie (Channel 1) 003 - 00014.tif
Movie (Channel 1) 003 - 00015.tif
Movie (Channel 1) 003 - 00016.tif
Movie (Channel 1) 003 - 00017.tif
Movie (Channel 1) 003 - 00018.tif
Movie (Channel 1) 003 - 00019.tif
File name:
Open
Files of type:
tif Image files (*.tif)
Cancel

The dialogue displays, by default, the location to open files associated with the imaging function i.e. the image file location used by Snapshot and Photo.

Save (Ctrl + S)

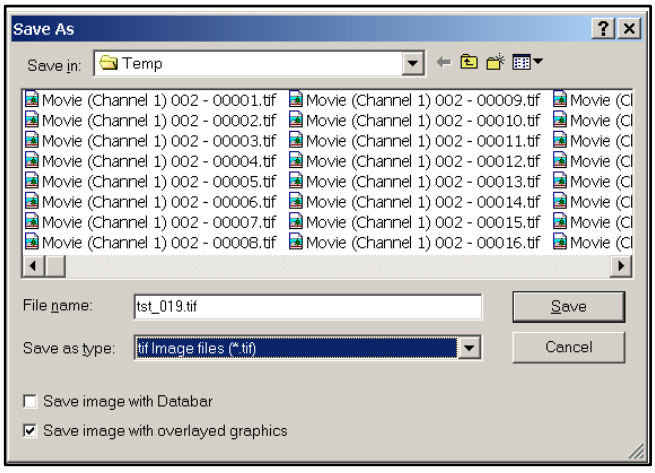
saves the image (**TIF** file format only) with a given (last used) name in that quad and an incremental label at a predetermined location (all can be set at the user´s first time log on). Any time you save an image, it is saved as a new file, e.g. Label_001.tif, Label_002.tif, etc.

Save As



opens a dialogue for saving images, which provides an opportunity to change the file name, its label or location. **TIF, JPG** and **BMP** file formats are available to save.

FIGURE 4-10 SAVE AS... DIALOG


Save As
Save in:
Temp
Movie (Channel 1) 002 - 00001.tif
Movie (Channel 1) 002 - 00002.tif
Movie (Channel 1) 002 - 00003.tif
Movie (Channel 1) 002 - 00004.tif
Movie (Channel 1) 002 - 00005.tif
Movie (Channel 1) 002 - 00006.tif
Movie (Channel 1) 002 - 00007.tif
Movie (Channel 1) 002 - 00008.tif
Movie (Channel 1) 002 - 00009.tif
Movie (Channel 1) 002 - 00010.tif
Movie (Channel 1) 002 - 00011.tif
Movie (Channel 1) 002 - 00012.tif
Movie (Channel 1) 002 - 00013.tif
Movie (Channel 1) 002 - 00014.tif
Movie (Channel 1) 002 - 00015.tif
Movie (Channel 1) 002 - 00016.tif
File name:
tst_019.tif
Save
Save as type:
tif Image files (*.tif)
Cancel
Save image with Databar
Save image with overlayed graphics

The dialogue displays, by default, the location to save files associated with the imaging function i.e. the image file location used by Snapshot and Photo. With this command, files will not be saved automatically to their existing labels if labels exist. You can also choose whether to **Save** the **image with /** without **Databar** and **with** / without **Overlayed graphics** by checking / unchecking appropriate check box.

Record Movie

allows the user to make of digital video files (AVI) for dynamic experiments performed within the Quanta FEG microscope. When clicking on the red dot icon, it changes to red square one (see Chapter 5 for a detailed description).

Import / Export

opens a sub-menu for file types, etc. This in turn leads to an import / export dialog for selection. Certain image files not produced by the FEI xT system can be imported, and files produced by the FEI xT system can be exported via this function.

STG files (Stage Positions) and **EPM files** (End-Point Monitor Graphs) are available to Import / Export.

FIGURE 4-11 FILE IMPORT / EXPORT MENU

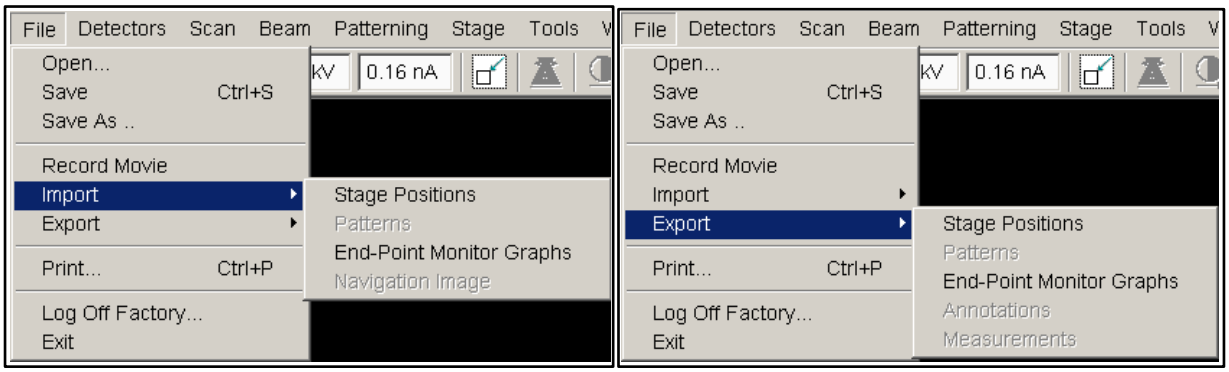
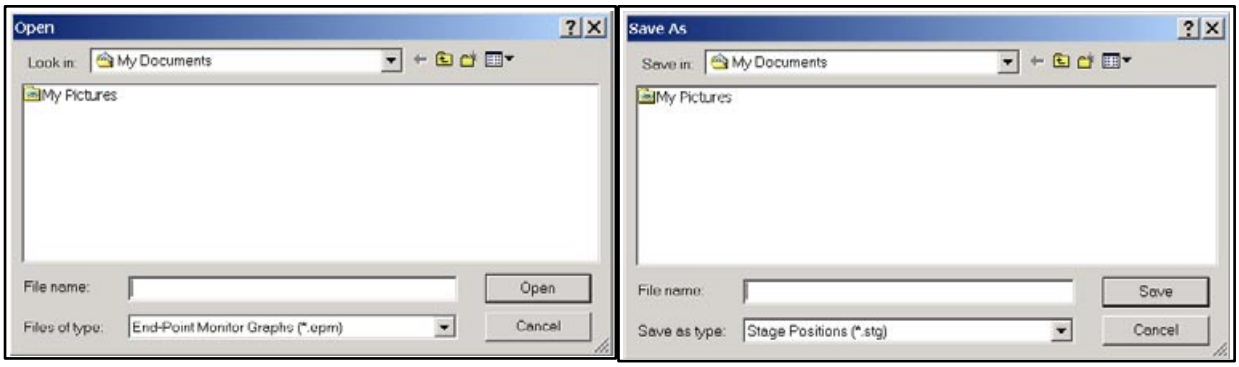


FIGURE 4-12 IMPORT / OPEN AND EXPORT / SAVE AS DIALOGS



Print (Ctrl + P)

opens the printer dialogue so that the choice of printer and conditions can be established to print an image or any other printable product from the microscope. Pressing **OK** in the printer dialogue will activate the printer to print the job.

Log Off

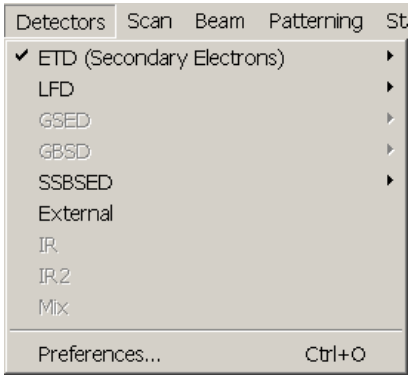
logs off the present user and provides a **Log On** dialogue for the next user of the microscope. The following conditions apply:

- When a user logs off the system goes to a safe state: the HV is switched off automatically.
- When closing the xT microscope Control software, the current user is automatically logged off first.

Exit (Alt + X)

exits the xT microscope Control software and leaves the user in the operating system environment. xT microscope Server is still running and controls the microscope in operation.

The Detectors Menu (Alt + D)



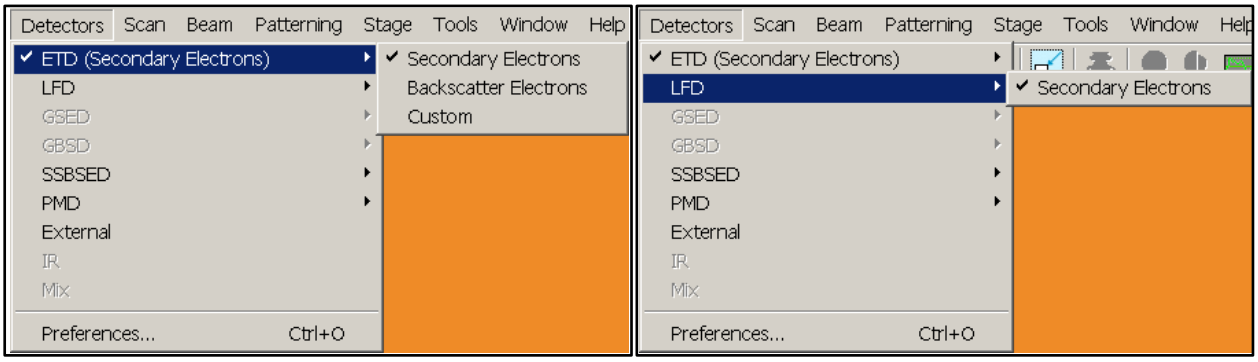
opens the Detector menu functions:

Detector list

may contain various detectors for E-Beam and I-Beam High Vac, Low Vac and ESEM operation. Depending on whether the relevant detectors is installed and available, all others will be greyed out. Only the selected detector for the active quad shows a tick next to its label.

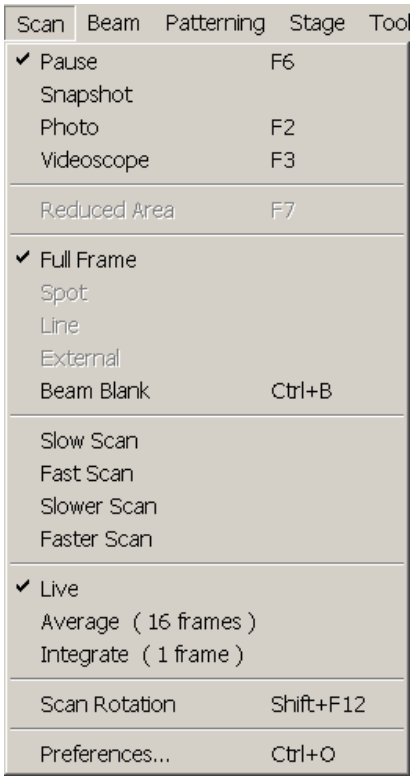
A detector can be customised by clicking on the small black arrow on the right of the **Detector** menu. This will open a secondary menu with the default operating modes at the top of the menu and a custom mode at the bottom. Clicking on the **Custom** label activates the mode, and this will be displayed after the detector label in the main menu.

FIGURE 4-13 DETECTOR SUB-MENU EXAMPLES



Conditions of bias/grid voltage or switching of segments of the Custom mode detectors can be initiated in the **Preferences... / Detector** tab. These will change in real time but do not interfere with the default settings for any detector.

The Scan Menu (Alt + S)



opens the Scan menu functions:

Pause (F6)

pauses the image. The behaviour of the pause function after clicking the icon can be set in the **Preferences... / General** tab:

- Stop at end of frame:
  clicking once – stops the scan at the end of the frame
  clicking twice – same as Stop immediately
- Stop immediately:
  clicking once – stops the scan immediately without continuing to the end of the frame

When Pause is active (the icon button is pressed in) a green box surrounding two vertical green bars appears in the appropriate imaging Quad. Clicking the icon releases the pause function (the icon button pops out) and returns the scanning to the previous state.

This function is used automatically with Snapshot.

Snapshot

activates a single preset scan which pauses at the end of the scan. The result can be stored with the File / Save function to the harddrive. Conditions for this function are predefined in the **Preferences... / Scanning** tab.

Photo (F2)

activates a single preset high quality, high resolution slow scan which pauses at the end of the scan. The resulting image can be stored on the harddrive with the File / Save function. Conditions for this function are predefined in the **Preferences... / Scanning** tab.

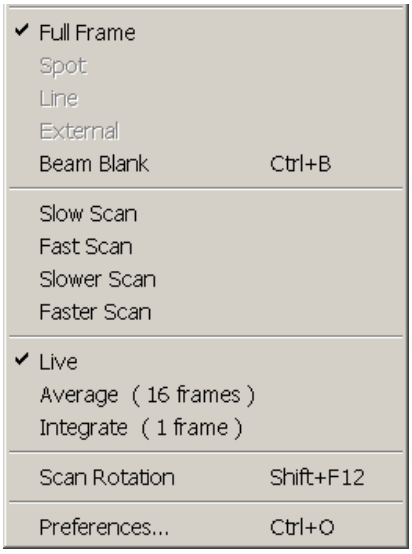
Videoscope (F3)

Videoscope toggles the display of the videoscope on or off, showing the video intensity along the currently scanned horizontal line for correcting contrast and brightness.

Reduced area (F7)

This mode is useful when focusing and stigmating as the scan speed is faster in the smaller area. When Reduced area is chosen, the small green area frame appears at the last known place on the screen, its area and position are adjustable by mouse. It is also possible to adjust scan parameters independently on the full-frame setting.

- Moving:
  Click and hold the left mouse button in the selected area. The arrow changes to a four-ended arrow. This will take time, depending on the actual scan speed. Drag the selected area to the desired position and release the mouse button.
- Changing the size:
  Click and hold the left mouse button at the edge of the selected area. The cursor changes to a two-ended arrow, either horizontal or vertical. A corner can also be used to size two sides at one time. Now drag the selected area out or in to the desired size and release the mouse button.
- Making a new one:
  Place the cursor outside of the selected area and make sure Get and Shift are not activated. The cursor should be the normal arrow symbol. Move the cursor to where you want the left upper corner of the selected area to be. Click the left mouse button and drag the cursor until the rectangle on screen includes the area you want to select. Release the left mouse button.



When the Reduced area frame is being manipulated, it turns yellow until released, then it reverts to green.

Full Frame

is the default scanning mode. This is the normal scanning mode, typical for general navigation.

Spot

brings you to Spot mode. The image pauses and the scaning is switched off. The spot position is represented by a green cross. You can drag the spot around the screen with the left mouse button.

Line

brings you to Line mode. The green horizontal line displays on the screen. The beam scans along this line, using the line time defined for the selected scan speed. You can drag the line up / down with the left mouse button.

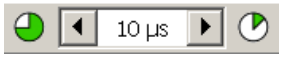
External

switches to activate external control of the scanning system, such as beam control from an EDX X-ray system.

Beam Blank (Ctrl + B)

deflects the beam off axis high in the column and protects the sample from unnecessary exposure to the beam. This is useful at the end of scanning when ready to save the image so that the sample is not continuously scanned before the next image.

When the beam is blanked the toolbar icon button is pressed. Clicking again on the button will release the blanker and return the beam to scan the sample.



Slow / Fast / Scan

brings the scanning condition to the preset Slow (left icon) / Fast (right icon) scan value, held in the **Preferences... / Scanning** tab.

Slower / Faster Scan

brings the scanning condition to the next Slower (left arrow) / Faster (right arrow) scan value held in the **Preferences... / Scanning** tab (which is displayed in the middle of the Preset / Continuous control).

When either of the two presets are active or selected the respective icon is highlighted. Clicking any of these items invokes a change to the scan speed.

Live

leaves the image unfiltered for collecting raw direct images - one frame follows another.

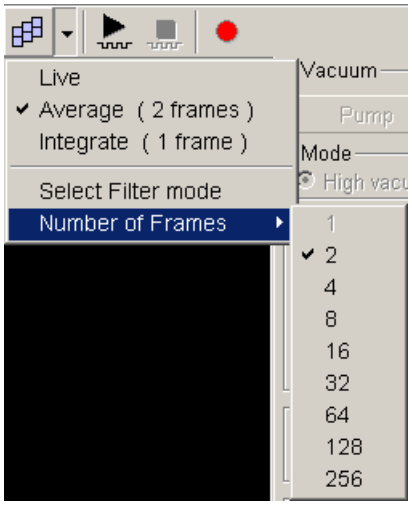
Average

continuously averages a specified number (two or more) of frames, resulting in a better signal-to-noise ratio. This process will continue until stopped by changing the scanning condition or by freezing the result.

This is used mostly for fast scanning to reduce image noise. During averaging, the image is updated continuously and actions such as focusing, moving the stage, etc. can still be performed. The number of frames can be selected as a preset in the toolbar drop-down list box associated with the Average function.

Integrate

allows accumulative noise reduction by true integration over a specified number (two or more) of frames to an end value. This process will continue until the predefined number of frames is reached and then stops and freezes automatically.



During and after image accumulation, you cannot change the focus or perform other image-influencing actions. The number of frames can be selected as a preset in the toolbar drop down list box associated with the Integrate function.

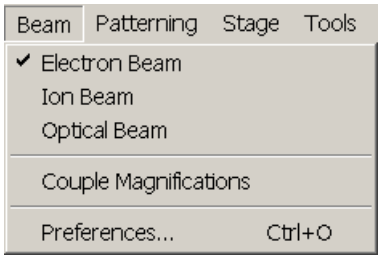
Note:
The Icon button passes from one function to the next when clicked. When the down arrow is clicked on the selection a dialog opens so that the functions can be loaded directly with frame values. The number of frames can be selected as a preset in the toolbar drop down list box associated with the Average / Integrate function. Clicking on one of these values causes the display to update to that condition. Frame values for Average and Integrate are independent of

each other, and of scan speeds, so values can be preset for particular scan, beam and quad conditions. A filter should be set for each quad and for each beam, so live and filtered images of a beam can be seen at the same time. If a new beam is chosen, filter reverts to the preferred setting for that beam.
The Integrate function is not available for the Optical Beam. The Average function is not recommended for the Optical Beam Quad when processing stage movements.

Scan Rotation (Shift + F12)

activates the onscreen tool to rotate the scan and align the image. It has no effect on the stage movements and is solely a scan coil function used to orient the image relative to mechanical rotation and detector direction.

The Beam Menu (Alt + B)



opens the Beam menu functions:

Electron / Ion / Optical / Beam

makes the quad or single screen active to the **Electron / Ion / Optical** beam (in the displayed sequence) with respect to source, column, scanning, and detectors. Only one is active at any time, but can be operated independently for each quad image area.

When the Optical Beam is active most of the remaining icons of the toolbar are inactive.

Couple Magnifications

Magnifications for the Electron and Ion columns can be coupled together, so that when switching between columns there is no difference in magnification.This is particularly useful when milling with the Ion Beam and viewing with the Electron Beam.

The Patterning Menu (Alt + P)

is for executing Patterning functions:

Start Patterning

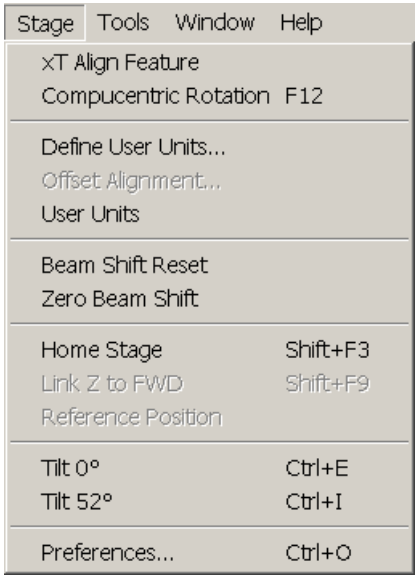
begins patterning with the pattern selected on the Patterning Page. When the icon button is active it changes to the **Pause Patterning**.

Reset Patterning

resets patterning to the beginning of the pattern procedure once again.

Note:
when patterning is started and a necessary condition is not available, a descriptive warning message appears in the Application Status… dialog box.

The Stage Menu (Alt + N)



opens the Stage menu functions:
(For a detailed description of the stage functions see Chapter 7 “Stages”.)

xT Align Feature

opens a procedure that helps one to navigate along a feature that extends off the screen at the current magnification.

Compucentric Rotation (F12)

places a green circle in the active quad. By rotating the circle a different viewing orientation of the sample area can be achieved by physical stage rotation and adjustment of X and Y axes. Stage rotation keeps the observed feature in the center of the field of view. If this does not occur, the “7 - Stage Rotation Centre” alignment should be performed to locate the stage center and calibrate stage (see Chapter 6 “Alignments”).

Define User Units...

activates a series of dialogues that guide the user to determine User Unit values for X and Y movements of the stage. These are used in relative movements associated with the stage mapping of regular features, in particular in IC applications.

Offset Alignment..

allows you to move to new points relative to the existing alignment but at a new location, for example, stepping between identical points on different dies quickly.

User Units

organises the stage software to recognise the defined user units rather than the default metric measurements. The X and Y coordinates now operate in User Units and are shown in the Location module by the UU symbol.

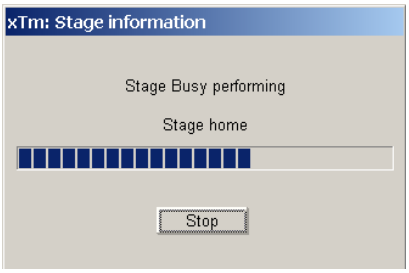
Beam Shift Reset

begins the procedure to zero the beam shift and move the feature to the center of the field of view with the stage.

Zero Beam Shift

restores X and Y beam shifts to zero values, when beam shift has reached maximum limits (computer beeps).

Home Stage (Shift + F3)



homes the stage. When the stage is homing the Stage Active dialogue box flashes onscreen. When the stage is homed correctly, the end position will be the last reference position stored.

All motorized coordinates will be set to default factory settings. These settings (see navigation page stage module) in general will be as follows:
X = 0.0, Y = 0.0, R = 0°, T = 0°,
Z = preset long working distance relative to stage type

Link Z to FWD (Shift + F9)

sets the Z coordinate value to actual Free Working Distance (FWD) value. This allows accurate movement between the known height of the sample and the end of the lens.

Note:
the icon button can be in one of the three following conditions:

- Coloured icon with a red question mark:
  the HV is on but the Z to FWD may not be correct. The function is disabled. This occurs after the system is vented until the vacuum is restored.
- Coloured icon with red line circling between the lens and baseline:
  Z to FWD needs recorrection. The function is enabled, but the Z-coordinate for the current sample has not been coupled to the FWD yet.
- Coloured icon with a double-ended arrow between the lens and baseline: Z to FWD is correct. The function is enabled, and has been already used for the current sample. It is still possible to reset the sample's Z-coordinate by pressing this button.

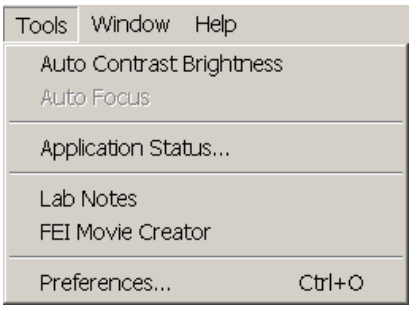
Reference Position

zeroes the stage coordinate values for X,Y, R and Tilt to establish a reference position for all further coordinates to refer to. The coordinate values in the **Stage Coordinates** module on the **Work Page** will indicate the new reference position.

Tilt 0° / 52° (Ctrl + E / I)

sets stage tilt to 0° / 52° – perpendicularly to Electron / Ion Beam.

The Tools Menu (Alt + O - *letter*)

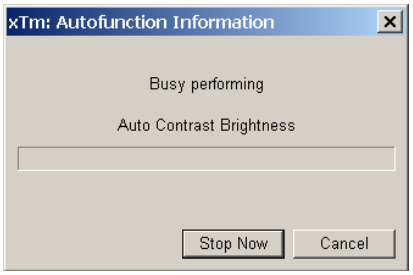


opens the Tools menu functions:

Auto Contrast Brightness

activates the automatic contrast and brightness routine. This function is available only for particular detectors mostly working in **High vacuum** mode. The system attempts a correcting of the contrast and brightness levels to suit the sample so that the majority of grey levels are displayed.

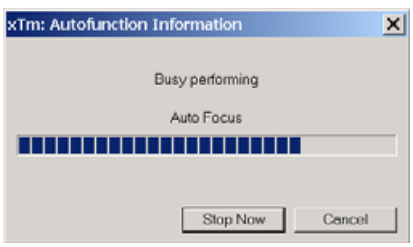
When activated, the dialogue appears, showing the progress. The function can be interrupted by clicking on the **Stop Now** button, which leaves the image at the current stage of progress. Clicking on **Cancel** before the function ends will return the image back to its original status.



Note:
ACB function is not available for gaseous detectors.

Auto focus (F11)

activates the automatic focus routine. The system attempts to correct the focus independent of the working distance or focus set.



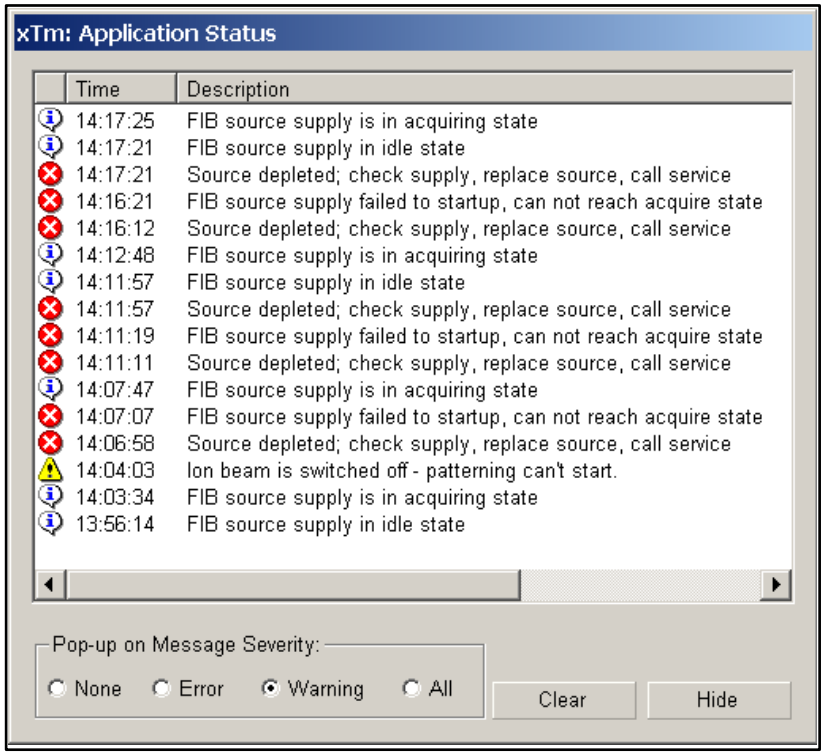
When activated the dialogue appears to show the progress. The function can be interrupted by clicking on the **Stop Now** button, which leaves the image at the stage of progress at stopping. Clicking on **Cancel** before the function ends will return the image back to its original status.

Application status...

displays a dialogue above Quad 4 showing any appropriate continuously updating system reports.

- Pop-up on Message Severity: None / Error / Warning / All
  this radio button specifies which kind of messages is going to to be shown automatically on screen.
- Clear button clears old messages from the window
- Hide button hides Application Status window

FIGURE 4-14 APPLICATION STATUS


xTm: Application Status
Time
Description
14:17:25 FIB source supply is in acquiring state
14:17:21 FIB source supply in idle state
14:17:21 Source depleted; check supply, replace source, call service
14:16:21 FIB source supply failed to startup, can not reach acquire state
14:16:12 Source depleted; check supply, replace source, call service
14:12:48 FIB source supply is in acquiring state
14:11:57 FIB source supply in idle state
14:11:57 Source depleted; check supply, replace source, call service
14:11:19 FIB source supply failed to startup, can not reach acquire state
14:11:11 Source depleted; check supply, replace source, call service
14:07:47 FIB source supply is in acquiring state
14:07:07 FIB source supply failed to startup, can not reach acquire state
14:06:58 Source depleted; check supply, replace source, call service
14:04:03 Ion beam is switched off - patterning can't start.
14:03:34 FIB source supply is in acquiring state
13:56:14 FIB source supply in idle state
Pop-up on Message Severity:
None
Error
Warning
All
Clear
Hide

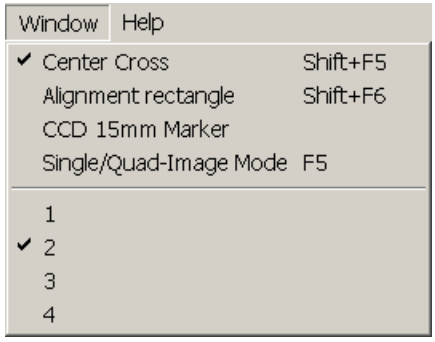
Lab Notes

opens the Windows NotePad application above Quad 4 for the user to make immediate notes and remarks. After entry of a note the file can be stored as a text file (.TXT). Any previous note can also be opened in Lab Notes.

FEI Movie Creator

provides a tabbed dialogue above Quad 4 for setting up a collection of sequenced TIF images, and sequencing them into an AVI movie.

The Window Menu (Alt + W)



opens the Window menu functions:

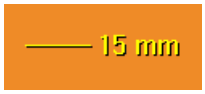
Center Cross (Shift + F5)

places a cross in the center of either the single screen or each quad depending on the display mode selected. This function is used in the Adjustment procedures to aid the centering of features and can be used to align a sample against a stored image in another quad.

Alignment rectangle (Shift + F6)

places a staggered rectangle in the center of either the single screen or each quad, depending on the display mode selected. This function is used in the Adjustment procedures to aid illumination control.

CCD 15 mm Marker



Clicking on the CCD 15 mm Marker places a short horizontal lines with arrow onto the optical beam quad. This is to indicate the 15 mm FWD position in relation to the Z distance of the sample.

The position of this marker can be changed by double-clicking with the left mouse button on the desired position.

Single/Quad-Image Mode (F5)

toggles the image display area between two posibilities:

- Single Image Mode
  uses one quad for the entire screen – useful for observing details.
- Quad Image Mode
  is useful for comparing images of the same sample area with different beams, detectors or scan properties.

1 / 2 / 3 / 4

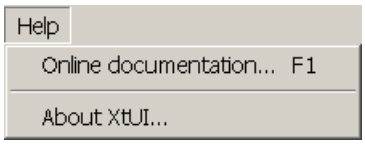
selects the Active Quad **(1 - 4)** by ticking the respective number. Quad 1 is top left and Quad 4 is bottom right, with the others running horizontally. All quads can contain live images with either Electron, Ion or Optical beam. The Status of the Quad is also defined by the Beam type (displayed by the beam icon) and whether it is paused or not (displayed by the pause icon).

Only one image window has focus at any time (recognizable by a light blue databar instead of a grey one), although the others can have live images.

Quad 3 can display a mixed image from quad 1 and 2 images and quad 4 can display a mixed image from quad 1, 2 and 3 images.

Note:
the detector incompatibility (BSD is incompatible with CCD) is the only restriction on the use of some combinations of Beam and Detector per Quad.

The Help Menu (Alt + H)



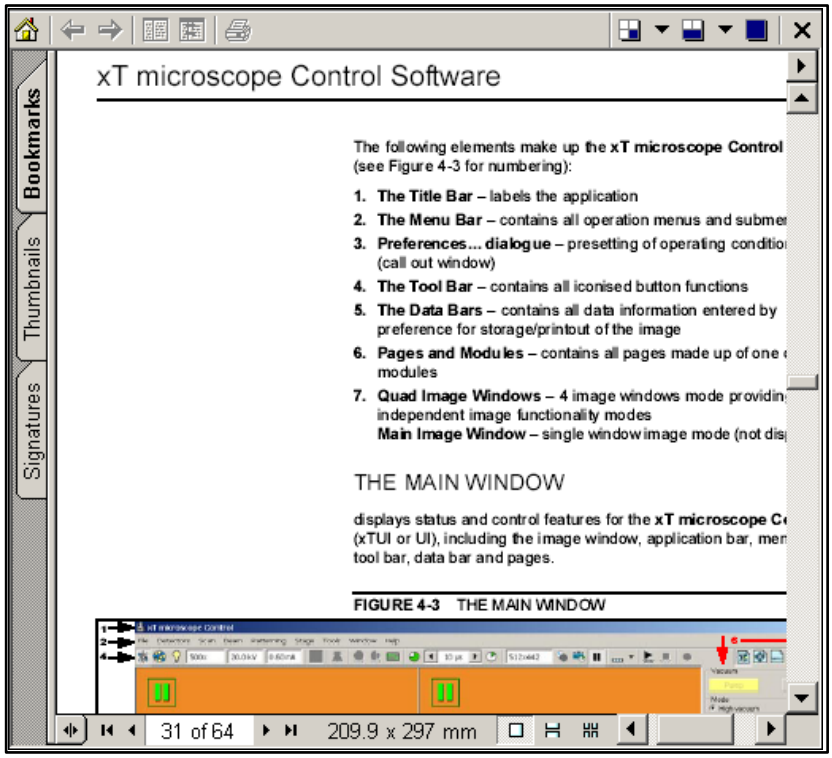
opens the Help menu functions:

Online Documentation... (F1)

The Help dialog area is defaulted to the bottom right quad at startup, and can be expanded to all quads for more detailed help including diagrams and images. It can also be dragged to any position on the available screen. The help box function remembers the position and size that the user last defined until returning to its default value on startup.

The Help window can be controlled from the listed buttons on the top right. These are useful if it is important to view the application at the same time.

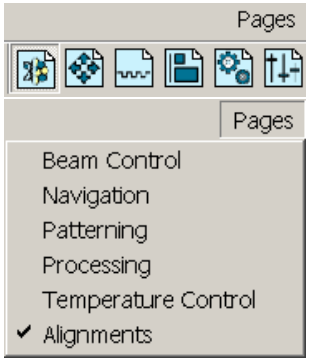
FIGURE 4-15 ON-LINE DOCUMENTATION .


Bookmarks
Thumbnails
Signatures
xT microscope Control Software
The following elements make up the xT microscope Control
(see Figure 4-3 for numbering):
1. The Title Bar – labels the application
2. The Menu Bar – contains all operation menus and submer
3. Preferences... dialogue – presetting of operating conditio
(call out window)
4. The Tool Bar – contains all iconised button functions
5. The Data Bars – contains all data information entered by
preference for storage/printout of the image
6. Pages and Modules – contains all pages made up of one
modules
7. Quad Image Windows – 4 image windows mode providin
independent image functionality modes
Main Image Window – single window image mode (not dis
THE MAIN WINDOW
displays status and control features for the xT microscope C
(xTUI or UI), including the image window, application bar, me
tool bar, data bar and pages.
FIGURE 4-3 THE MAIN WINDOW
31 of 64
209.9 x 297 mm

About XtUI... (xT microscope Control)

displays the software version, software build number and date of release.

Pages and Modules



The software controls on the right side of the screen are organized into **Pages**. Pages are further divided into smaller **Modules** that hold specific functions. The frequently used controls appear as modules on more than one page. The required page can be selected either from the Pages menu or by pressing the corresponding icon button on the right side of the toolbar.

TABLE 4-2 PAGES LIST

Pages	Modules (Tabs)
Beam Control	Vacuum / Mode, System, Column, Beam, Magnification, Electron Beam Curren, Detectors, Status
Navigation	Stage (Map, Coordinates), Beam, Smart Scan, Detectors, Status
Patterning	Pattern / Progress, Gas Injection (Overview, Details), End Point Monitor (Graphs, Options, Scaling), Status
Processing	Measurement, Annotations, Enhance Image, Status
Alignments	Alignments, Instructions, Individual steps, Status
Temperature Control Page	Vacuum / Mode, Temperature Stage Control / Temperature Profile, Beam, Detectors, Status

PAGES COMMON FEATURES AND MODULES

Column Type

Electron Beam

Ion Beam

Optical Beam

Some of the module controls are dependent on column type. In this case, the column type in active operation is indicated by the icon representing either the Electron or Ion column for the active quad image window at the right side of the module.

Note:
when Optical beam is selected, the pages function is not available.

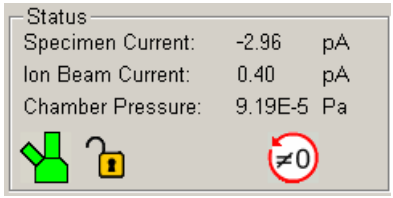
Tool Tips

Allowing the cursor to dwell shortly over some icons or the Status area texts gives other information or more precise values as a tool-tip window.

Progress Bar

can be found where the operating function progresses over time, such as in patterning. The time lapse is indicated by a progressing green bar.

The Status Module



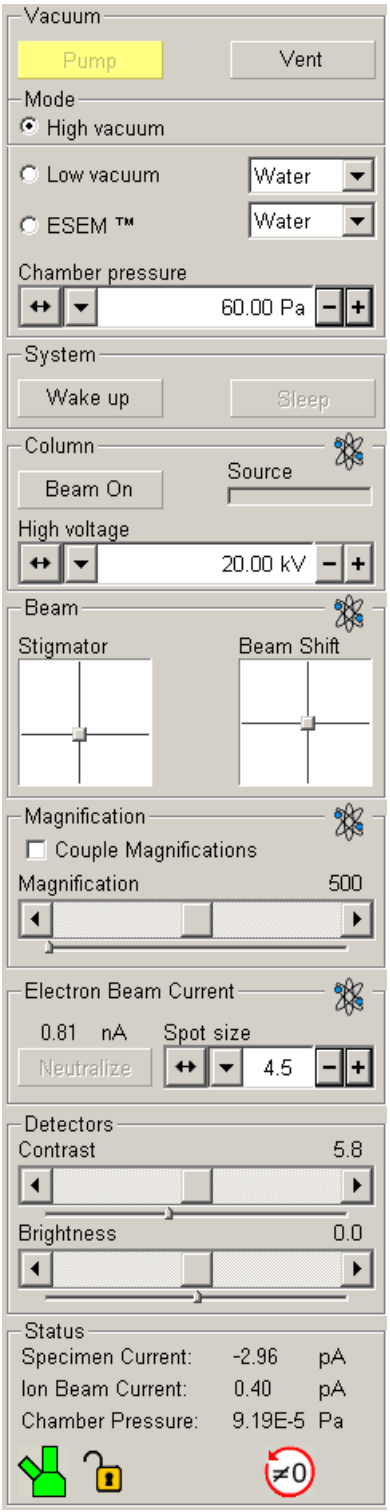
can be found at the base of all pages displaying important current system parameters and animated icons. These parameters may change due to the application being monitored at any time.

- **Specimen Current** shows the total current absorbed by a specimen, assembled from Electron source current, Ion source current and current produced by detectors.
- **Ion Beam Current** shows the primary Ion Beam current. This value is correct only when imaging is paused, otherwise the value cannot be considered.
- **Chamber Pressure** shows pressure in the specimen chamber, depending on mode selected, kind of specimen, etc.

TABLE 4-3 STATUS ICON FUNCTIONS

Icon	Function
	Dual column and Chamber vacuum – Vented
	Dual column and Chamber vacuum – Pumping
	Dual column and Chamber vacuum – Vacuum
	Stage axes – Lock (any one) / Unlock (all)
	Dynamic Focus On
	Scan rotation not zero
	External scanning mode On

Beam Control Page



The Beam Control Page is an FEI User level page containing the essential components divided into the following modules:

- **Vacuum / Mode** module
  is used to pump the system into either HiVac, LowVac or ESEM mode and to vent the system.
- **System** module
  brings the system to Sleep / Standby / Full Operation states (see Chapter 3).
- **Column** module
  controls High Voltage switching on or off.
- **Beam** module
  contains Stigmator and Beam Shift controls.
- **Magnification** module
  contains Magnification controls.
- **Electron Beam Current** module
  allows Charge Neutralization start and Spotsize value setting.
- **Detectors** module
  allows adjustment of contrast and brightness for the currently used detector.
- **Status** module (common for all pages)
  contains important information about the system.

THE VACUUM / MODE MODULE

is used during specimen exchange or to change the instrument status in and around the final lens pole.

The Pump Button

starts the pumpdown procedure for the column and the specimen chamber. When the chamber is evacuated, the system allows high voltage to be switched on when the pressures in the chamber and the column are ready for operation.

The Vent Button

initiates the following sequences:

- Electron Column: Switches High Voltage off.
- Ion Column: Blanks the beam is and closes the Column Isolation Valve (CIV). Initiates the largest aperture and switches to the lowest High Voltage.
- The GISes: close and retract but stay heated

The parameters of the column are not affected. Venting the chamber opens the specimen chamber valve for a period of time and then closes it. If the valve is closed again before the chamber is at ambient pressure, another click on the Vent button repeats the procedure.

High Vacuum / Low Vacuum / ESEM Modes Radio buttons

bring the system to either:

- HiVac operation when observing conventional samples
- LowVac for observing non-conductive or partially conductive samples

- ESEM Mode for observing natural status of samples at pressures above 130 Pa (1 Torr)

According to the detector used, the system sets the default condition.

The purging medium can be selected from the drop-down list boxes to suit the sample observation. The **Pressure** adjuster can be used to adjust the pressure to suit the operation of either LowVac or ESEM modes. This is chosen either by the adjuster, which is continuous, or from the list, where a preset value can be selected.

THE SYSTEM MODULE

initiates the following sequences:

Wake Up button:

- starts the Ion source
- switches on the Electron Beam
- heats the GISes, that had been heated when the Sleep button was pressed the last time

Sleep button:

- stops the Ion source
- switches off the Electron Beam
- cools the GISes

THE COLUMN MODULE

contains the same controls for the Electron beam and the Ion beam:

The Beam On Button

initiates the following sequences for the respective columns:

- Electron column: switches High Voltage on or off and heates the filament
- Ion column: opens / closes the CIV, blanks / unblanks the beam, selects the last / smallest aperture, selects the last / lowest High Voltage

When activated / deactivated, the button changes from gray to yellow / yellow to grey.

The High Voltage Control

changes the applied accelerating voltage. The actual value of the high voltage displays in text area of the adjuster and in the data bar (if selected). A preset value can be chosen by selecting one of the voltages from the drop-down list. The adjuster also has a slider mechanism for finer adjustment.

- The Electron column ranges from 200V to 30kV
- The Ion column ranges from 5kV to 30kV

The Source Indicator

shows the progress of the beam source startup procedure.

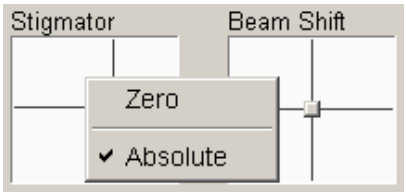
THE BEAM MODULE

displays controls that are used by both Electron and Ion beams.

The Stigmator Control

corrects image astigmatism via a 2D control. The crosshair indicates the actual setting of the stigmator.

Pressing and holding the left mouse button anywhere inside the 2D control causes the cursor to move to the screen position corresponding to the actual astigmatism value (minimum in the middle of the screen and maximum at the edges). Moving the mouse activates a four-ended arrow cursor with which one can correct the astigmatism: Left-Right / Up-Down moves modify the X / Y stigmator. Note that the stigmator range is coupled with the magnification.



Pressing the right mouse button above the Stigmator 2D control displays a menu that enables reseting the stigmator (**Zero**) and toggling between the linear (**Absolute** checked) and logarithmic control response.

You can also use the Shift + right mouse button for stigmation.

The Beam Shift Control

indicates and controls the beam shift setting via a 2D control in relation to the final lens axis. It is useful for fine image shift without stage movement. The control behaviour is the same as described for the Stigmator.

THE MAGNIFICATION MODULE

The Couple Magnifications Check box

binds the magnification of both beams together. Changing the magnification under one beam causes it to change in the same orientation under the other one. If greyed, the magnification cannot be coupled, for various reasons, including different limit values for the two beams.

The Magnification Control

offers the variable control. The linear mini-slider keeps its actual position and is placed below the non-linear main sliders, which return back to the centre after a movement.

- Clicking the end arrow increases magnification by about 5%.
- Clicking between the end arrow and the adjuster increases magnification by about 20%.
- By dragging the slider changes the magnification exponentially. The further from the centre, the greater the magnification change.
- By dragging the mini-slider changes the magnification linearly and coarsely.
- Clicking the * (star key) gives a round magnification number.

THE ELECTRON BEAM CURRENT MODULE

The Neutralize Button

switches the **Charge neutralization** mode on or off. This is a special electron beam mode used for ion beam milling of non-conductive samples. The ions can positively charge the sample causing an image drift and spoiling the beam probe quality. In charge neutralization mode, the electron beam produced by the electron beam column is used to compensate for the positive charging. The electron beam is unblanked during the milling. It does not scan and is usually strongly defocused.

How to use the charge neutralization:

1. Switch on the electron beam. Set the eucentric working distance and find the area of interest. Tilt 52°. Pause all electron beam quads.
2. Select a small ion beam current (<100 pA) and image an area close to the place you want to mill with ions. Pause the ion beam quads.
3. Select the ion beam current for milling.
4. In the **Preferences / Charge Neutralization** tab optimize the charge neutralization parameters so that there are no charging effects visible in the ion beam image. The image must be stable in position, focus and brightness. Start with the **High Voltage** about 1 kV, approximately three times higher electron beam current than the ion beam current and the maximum negative **Defocus**. When using high **Spotsize** (> 6) optimize the current with **Source Shift**. If the neutralization is not sufficient increase the High Voltage.
5. Press the **Neutralize** button, unpause the ion beam quad.
6. Select the area for milling and pause the ion beam quads.
7. Set the milling patterns.
8. Start the milling. Check periodically using Snapshot if the ion beam image does not drift.

The Spotsize Preset / Continuous Control

allows a change of the **Spotsize** in continuous values from 1 to 10 using a adjuster and from 1 to 8 from a drop-down list. The selected spotsize is displayed in the text area of the adjuster (and in the data bar if selected).

This figure is another expression of the Beam Current found on the toolbar and is bound with it. When the Spotsize changes, the value in the list box changes too.

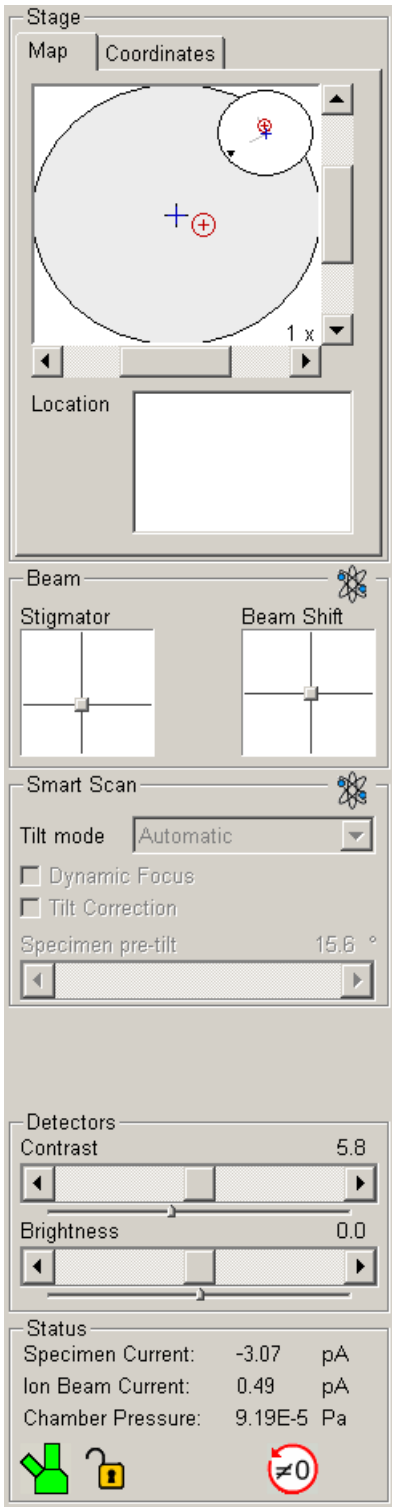
THE DETECTORS MODULE

The linear mini-sliders keep their actual position and are placed below the non-linear main adjusters, which return back to the centre after a movement. The end arrows give a finer control.

The Contrast / Brightness Control

controls the contrast / brightness of the active detector.

Navigation Page



The Navigation Page is an FEI Microscope User level page containing the essential navigation components divided into the following modules:

- **Stage** module
  integrates various functions related to the specimen stage.
  All functionality is described in Chapter 7 “Stages”.
- **Beam** module
  contains Stigmator and Beam Shift controls.
- **Smart Scan** module
  contains correction features for the tilted image.
- **Detectors** module
  allows adjustment of contrast and brightness for the currently used detector.
- **Status** module (common for all pages)
  contains important information about the system.

THE STAGE MODULE

allows control of the stage for positioning, location store / recall and mapping of coordinates.

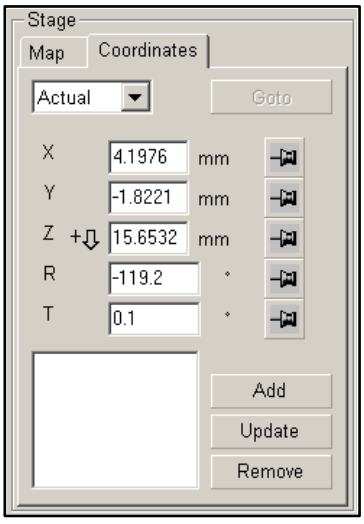
The Map Tab

displays the location of positions on the stage in a visual map form and in a list for selection. When clicked on, the stage is driven to the position selected. These positions can be stored in a file and contribute to a map of locations that can be reintroduced at a later date for reinvestigation of the same sample.

The Coordinates Tab

displays numerical information about a particular position when selected from the location list. Position values can be entered to drive the stage to a set position. Coordinates can be Actual, Target or Relative. Any or all movements can be locked. The stage lock for any of the axes is graphically displayed in the Status area as an open or closed lock.

FIGURE 4-16 TABBED STAGE COORDINATES DISPLAY



THE SMART SCAN MODULE

contains correction features for the tilted image. When the appropriate check box is ticked, the function becomes active. Dynamic Focus and Tilt Correction can only be used with scan rotation at zero.

Note:
this module is useful only for Electron Beam.

The Tilt Mode List box

gives a choice of selecting **Manual / Automatic** operation of the Dynamic Focus and Tilt Correction.

The Dynamic Focus Check box

The scan slowly proceeds from top to bottom and the focus point is automatically changed according to the positive tilt of the specimen. The focus should be sharpest in the middle of the image.

Dynamic Focus is usually used at low magnifications. It can be used for a strongly tilted specimen (either by the specimen surface itself or by stage tilt) when the depth of focus is not sufficient. It results in an image with overall sharpness.

The Tilt Correction Check box

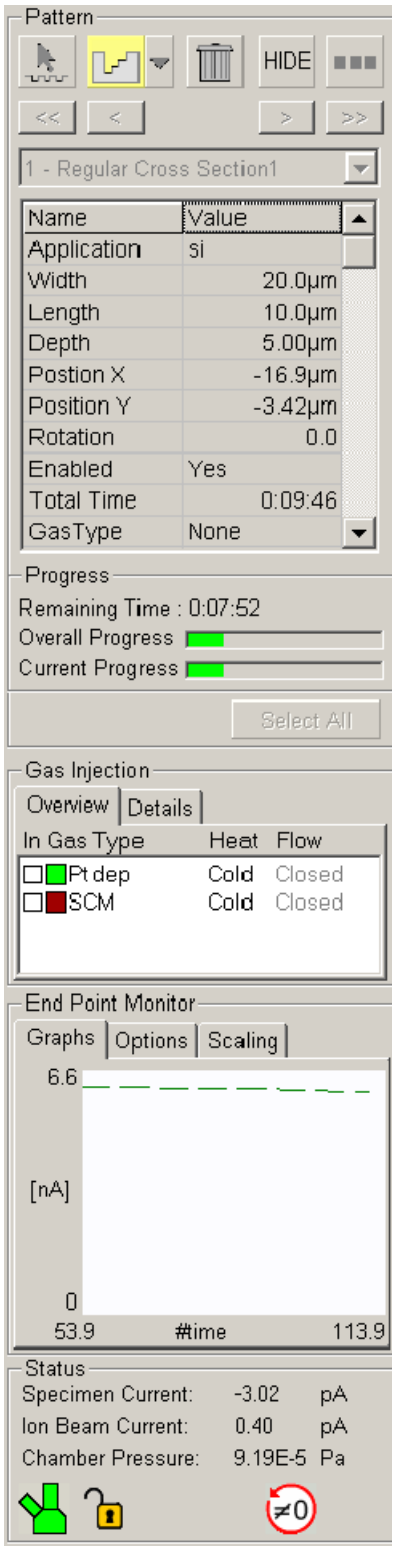
compensates for foreshortening in one direction on a flat specimen at a known tilt angle (80° range) and when the tilt axis is parallel to the scan line.

Because the image is a two-dimensional representation of a three-dimensional object, certain projection distortions occur. The more highly tilted the specimen is, the more foreshortened its image will be. For example, a square grid image will appear rectangular when you tilt the specimen. Applying tilt correction will correct the aspect ratio and restore the square appearance.

Specimen Pre-tilt Control

You must enter the specimen tilt angle on the adjuster for the calculations to be accurate.

Patterning Page



The Patterning Page is an FEI Microscope User level page containing the essential components to perform Patterning divided into the following modules:

- **Pattern / Progress** module
  enables pattern shapes selection, displaying, drawing and entering.
- **Gas Injection** module
  provides the capability to select the type of gas deposition or etching.
- **End Point Monitor** module
  gives visual feedback about the accuracy and progress of a milling process.
- **Status** module (common for all Pages)
  contains important information about the system.

All functionality of above modules (except Status one) is described in the Chapter 5 - Operations.

THE PATTERN / PROGRESS MODULE

A shape can be selected and handled by using the icons on the top of the module. The pattern is allocated a number relative to that shape and is displayed in the pattern list. When the pattern selector displays a blue shape, that shape can be drawn in the selected quad with the small cross cursor.

- **The Progress indicator** displays the Overall / Current Progress (over time) of the active patterning.
- **The Select All Button** selects all patterns in the list.

THE GAS INJECTION MODULE

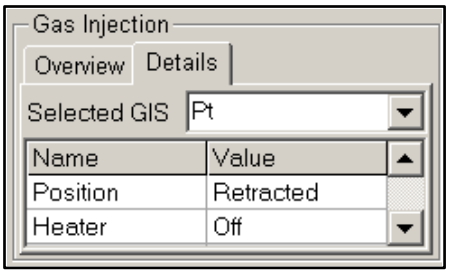
Overview Tab

- In check box: In (checked) / Out (Unchecked)
- Gas Type check box: the gas assignment to the port
- Heat status: Cold / Hot
- Flow status: Closed / Open

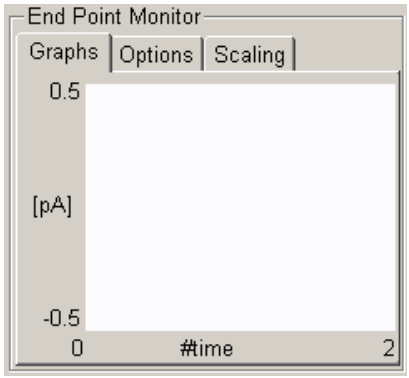
The Details Tab

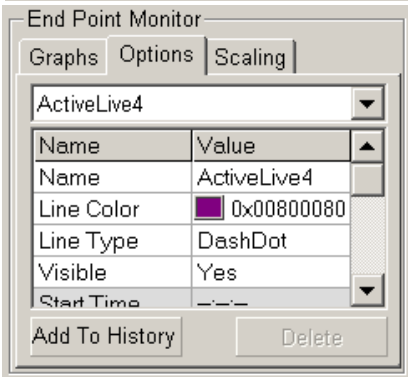
displays the characteristics of the active Gas Injector, which can be changed by entering the details to configure the injector.

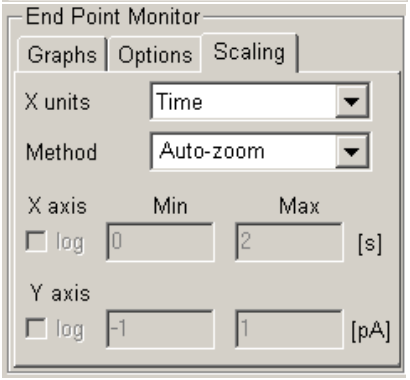
FIGURE 4-17 TABBED GAS INJECTOR DETAILS



THE END POINT MONITOR MODULE (EPM)







can be activated to start when patterning starts, stop when patterning is paused and restart when patterning is continued.

The Graphs Tab

illustrates in real time the cutting depth progress monitored by specimen current. This means the milling progress can be observed as a colored graphical display, showing the accuracy for depth over the whole milled area.

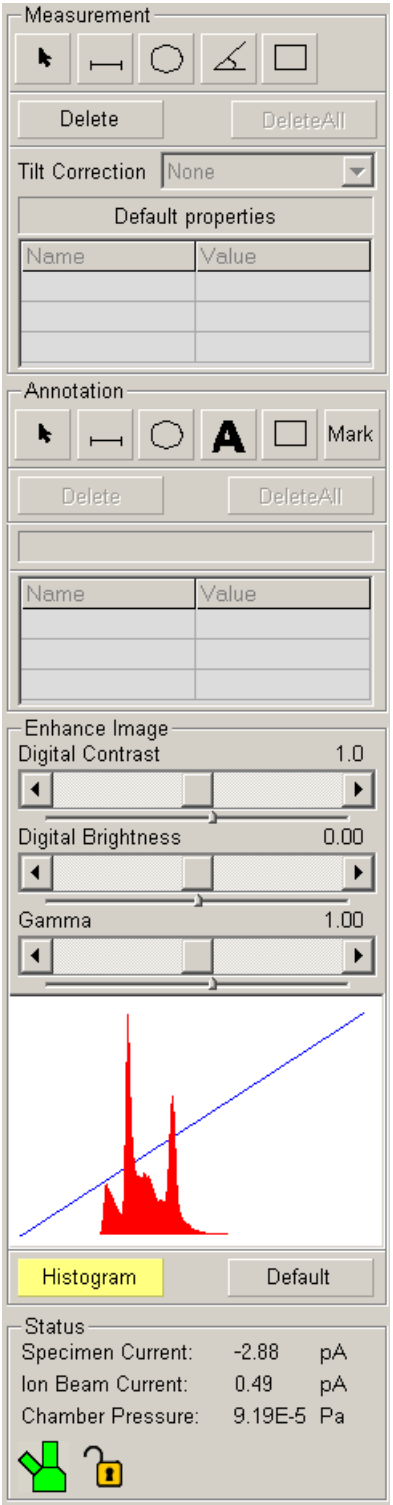
The Options Tab

allows the selection of any number of the milling processes being monitored to be graphically displayed.

The Scaling Tab

- **X Units:** Time / Depth
  corresponds to how the progress is observed
- **Method:** Auto-zoom / Fixed-zoom / Auto-pan

Processing Page



The Processing Page is an FEI Microscope User level page divided into the following modules:

- **Measurement** module
  give the user capabilities to measure linear distances, angles, diameters and areas, etc.
- **Annotation** module
  gives the user capabilities to locate and label items that are of significant interest on the sample area.
- **Enhance Image** module
  offers instruments for image improvements.
- **Status** module (common for all pages)
  contains important information about the system.

THE MEASUREMENT MODULE

Numerical values are updated while drawing and are displayed alongside or within the finished measured item. Selection of individual properties can be made in the **Default Properties** editor, some of which operate dropdown choices, such as color for instance.

THE ANNOTATIONS MODULE

allows the user to draw on the full screen or the active quad for purposes of highlighting features by displaying linear distances, circles, areas or text. Selection of individual properties can be made in the property editor, some of which operate dropdown choices, such as color for instance.

THE ENHANCE IMAGE MODULE

These digital functions are applicable separately to any image quad, while live imaging, and in contrast to similar detector functions. The image enhancement proceeds by converting the incoming signal to grey levels – manipulation of LookUpTable (LUT). It can also be used to adjust the CCD image illumination in the Optical Beam Quad.

- Digital Contrast Control:
  enables contrast to be set in range from -10 to +10
  (negative values lead to an inverse imaging)
- Digital Brightness Control:
  enables brightness to be set in range from -2.0 to 2.0
- Gamma Control:
  corrects image brightness non-linearly in range from -10 to +10

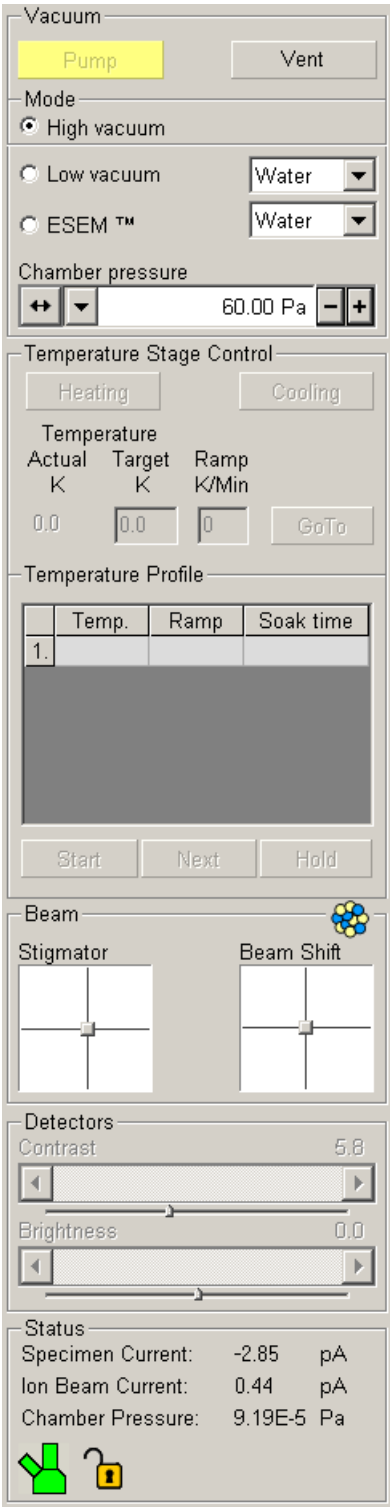
The Histogram Button

switches the graphical expression of active image shade densities on or off. The X-coordinate changes from black to white while the Y-coordinate changes from zero to the full density of the appropriate shade.

The Default Button

brings the above described function settings for the active quad back to the default values (no modification).

Temperature Control Page



The **Temperature Control Page** is an FEI Microscope User level page containing the essential components divided into the following modules:

- **Vacuum / Mode** module
  is used to pump the system into either HiVac, LowVac or ESEM mode and to vent the system.
- **Temperature Stage Control / Temperature Profile** module
  controls operation of optional heating or Peltier cooling stages.
- **Beam** module
  contains Stigmator and Beam Shift controls.
- **Detectors** module
  allows adjustment of contrast and brightness for the currently used detector.
- **Status** module (common for all pages)
  contains important information about the system.

This is an optional page which is delivered with either a heating stage(s) or a Peltier cooling stage.

THE TEMPERATURE STAGE CONTROL / TEMPERATURE PROFILE MODULE

switches between the heating stage or the Peltier cooling stage via the two buttons at the top of the module. The modules appearances are only slightly different (no ramp for the Cooling stage). If only one of these items is present on the Quanta 3D system then the other is greyed out.

Note:
the cooling module is shown here.

The Heating / Cooling Stages

Full functionality of the Temperature Stage Control for the heating / cooling stages can be found in Chapter 9 “Options”.

Alignments Page

Alignments
1 - Source Control
2 - Tetrode Alignment
3 - Gun Alignment
4 - Condenser Alignment
5 - Final Lens Alignment
6 - Stigmator Alignment
7 - Stage Rotation Centre
8 - PLA Centering
9 - Filament Exchange
100 - ION: Source Control
101 - ION: Aperture Alignment
102 - ION: Stigmator Balance
No step

The **Alignments Page** an FEI Supervisor User level page divided into the following modules:

- **Alignments** module
  displays the list of alignment procedures available to the supervisor.
- **Instructions** module
  displays key procedural information for the alignment step in operation.
- **Steps** module
  ranges from 0 - # and indicates the actual step position during an alignment procedure.
- **Status** module (common for all pages)
  contains important information about the system.

The alignment procedures are used to align the column and determine fine tuning for the electromagnetic system. The software stores column parameters such as Gun Tilt X, Y, Gun Shift X, Y, and other data that ensures minimum image shift when focusing and stigmating images.

Note:
Alignments should be performed by authorized FEI Service personnel or authorized supervisors with an appropriate level of understanding. Improper alignments can make the system difficult to use.
Please read Chapter 6 “Alignments” fully before proceeding with these adjustments.

THE ALIGNMENTS MODULE

Any possible alignment can be choosen from the List box:

- 1 - Source Control
- 2 - Tetrode Alignment
- 3 - Gun Alignment
- 4 - Condenser Alignment
- 5 - Final Lens Alignment
- 6 - Stigmator Alignment
- 7 - Stage Rotation Centre
- 8 - PLA Centering
- 9 - Filament Exchange
- 100 - ION: Source Control
- 101 - ION: Aperture Alignment
- 102 - ION: Stigmator Balance

FEI User management Software

The FEI User management software allows to FEI Account Admistrators, FEI Supervisors and FEI Microscope Users to organise users and accounts that can possibly be applied to the Quanta 3D. It allows the creation and removal of user accounts, the setting of user passwords and group membership, as well as the copying and removal of user data.

You can start the software by clicking the desktop icon (Start\Programs\FEICompany\UserTools\FEIUsermanagement.exe). This brings up the **Log On** dialogue box, containing **Username** and **Password** text fields, for entering the User Management software.

CONTROL POSSIBILITIES

Context menu

You can reach some context options by clicking the right mouse button. The use of these options is the same as described below.

Drag and Drop actions

Instead of using menu options, you can sometimes simply drag and drop items from one icon to another (set user group).

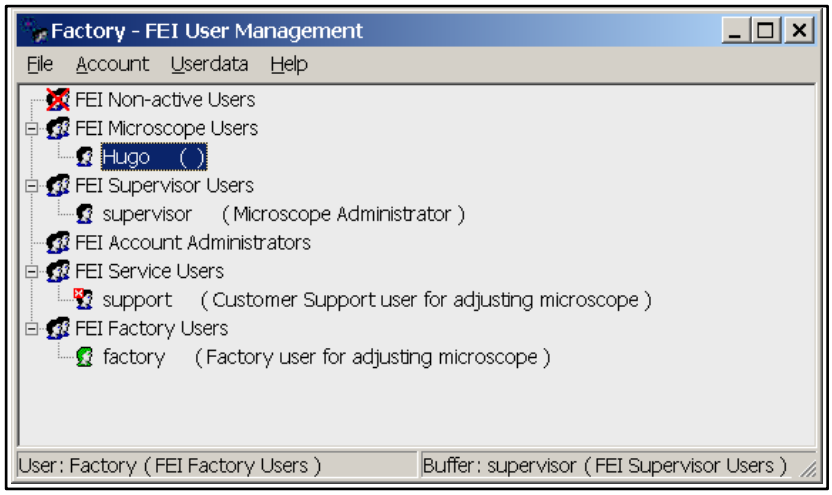
FEI ACCOUNT ADMINISTRATORS

As the highest account level, FEI Account Administrators have rights that allow them to create and delete users and change their properties over the following user groups (in order of significance):

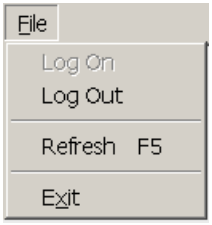
- FEI Account Administrator
- FEI Supervisor Users
- FEI Microscope Users
- FEI Non-active Users

Each of these accounts has its own opportunity to operate the **xT microscope Server** and **Control** software. The first FEI Account Administrator is created during the system installation.

FIGURE 4-18 FEI ACCOUNT ADMINISTRATORS CONTROL OVERVIEW


Factory - FEI User Management
File Account Userdata Help
FEI Non-active Users
FEI Microscope Users
Hugo ( )
FEI Supervisor Users
supervisor (Microscope Administrator)
FEI Account Administrators
FEI Service Users
support (Customer Support user for adjusting microscope)
FEI Factory Users
factory (Factory user for adjusting microscope)
User: Factory (FEI Factory Users)
Buffer: supervisor (FEI Supervisor Users)

THE FILE MENU

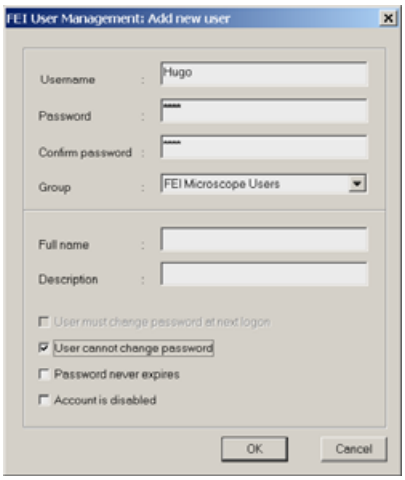


contains the following items:

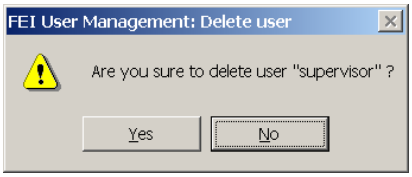
- **Login:** click to log in (active when user is logged out).
- **Logout:** click to log off (active when user is logged on).
- **Refresh (F5):** click to refresh the user tree.
- **Exit:** click to exit the FEI User management program.

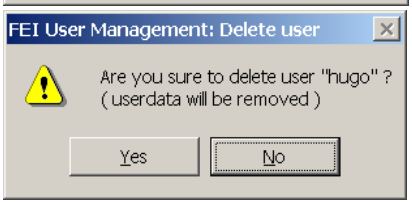
THE ACCOUNT MENU

contains the following items, which are accessible only for **FEI Acount administrators** (with the exception of set password function).



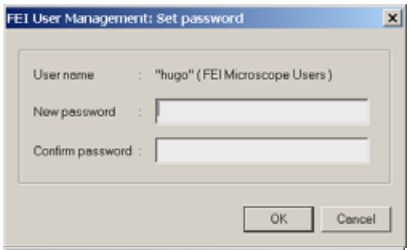
- **Create (Ins):** click to add a new user or supervisor.



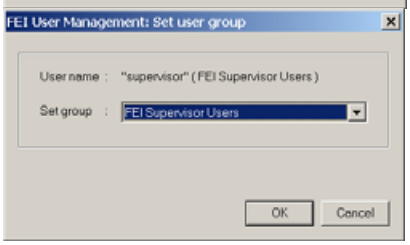


- **Remove (Del):** click to remove an existing user. The user must be highlighted first.

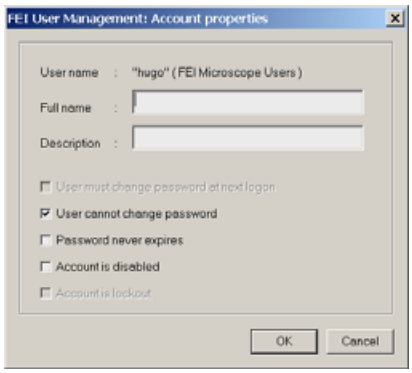
If an FEI Microscope User has user data, the account administator is warned that user data will be removed also. If any additional user is to be removed, that additional user´s data is removed without warnings.



- **Set password:** click to make a password for the user. The user must first be highlighted in the tree.
  An FEI Account Administrator can change the password for any user from a lower level account. The password has to be confirmed twice.

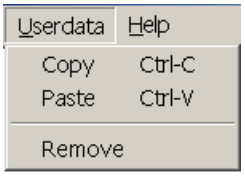


- **Set user group:** click to set the group for the user. The user must first be highlighted in the tree. When confirmed, the user is moved to selected group. When moving a user from the FEI Microscope Users group to the FEI Non-active Users group, his user data will be removed. A warning is displayed in this case.



- **Properties (Alt + Enter):** click to see and change the properties for that user. The user must first be highlighted in the tree.

THE USERDATA MENU

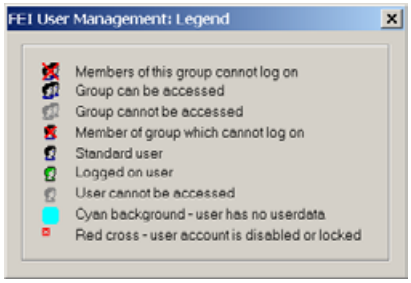


contains the following items.

- **Copy (Ctrl + C):** click to copy user data from a user of the same or a lower level group.
- **Paste (Ctrl + V):** click to paste user data into your own account or into the accounts of a lower group level. It is not possible to copy user data inside the FEI Supervisors User group.
- **Remove:** click to delete user data from a selected account of equal or lower group level.

THE HELP MENU

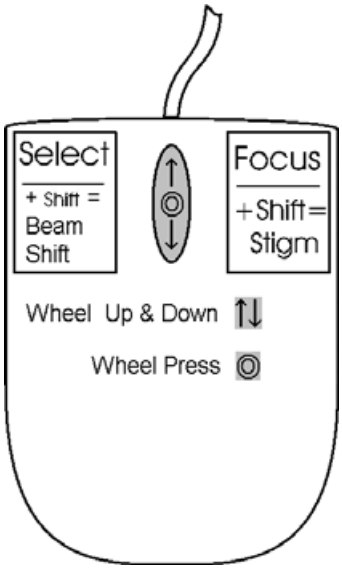
contains the following items:


FEI User Management: Legend
Members of this group cannot log on
Group can be accessed
Group cannot be accessed
Member of group which cannot log on
Standard user
Logged on user
User cannot be accessed
Cyan background - user has no userdata
Red cross - user account is disabled or locked

- **Legend:** clicking provides an explanation of icons used in the tree.

- **About:** displays the User Management software version and copyright.

Entering Commands in Summary



USING THE MOUSE

TABLE 4-4 MOUSE BUTTON FUNCTIONS

(Key +) Button	Function
Left	**Control Areas:** *makes selection* in control areas (single arrow cursor). **On Screen:** click and drag a *selected area* to *zoom in* in magnification to fill the image area with the selection (quad or full screen). **Lens Alignment Mode:** click and Drag provides the *final lens fine alignment* (four-ended arrow cursor). ***Double Click:*** Electron / Ion Beam Quad: *move the selected point* to the middle of the quad. Optical Beam Quad: *10 mm marker placement*.
Left + Shift	**On Screen:** click and drag a *selected area* to *zoom out* in magnification the screen (quad or full screen) to fit the selected area.
Shift + Left	Activates *Beam Shift* (hand cursor)
Right	To *focus* with the mouse, press and move the mouse to the left or right (double ended arrow cursor). Release the button to set the focus.
Shift + Right	To *stigmate* the image, press and move the mouse to the left or right (X stigmator), or up or down (Y stigmator) to correct (four-ended arrow cursor). Release the buttons to finish.
Shift + Wheel Up / Down	**Fine Control:** moving the wheel *increases / decreases the magnification*.
Ctrl + Wheel Up / Down	**Coarse Control:** moving the wheel *increases / decreases the magnification*.
Wheel Press	**Electron / Ion Beam Quad:** with the wheel pressed like a button the *TRACK mode* for joystick-like movement over the sample surface is activated. **Optical Beam Quad:** activates the *stage Z movement*. With the wheel pressed, moving the mouse up or down moves the Z up or down. This activity can be seen live in the Optical Beam Quad window.

Note:
the given sequence of key and button pressing is important for some functions.

USING THE KEYBOARD

TABLE 4-5 WINDOWS SYSTEM KEYS

Key (+ Key)	Function
Enter	Equivalent to *OK* in a dialogue box.
Esc	1. Equivalent to the *cancel* button. 2. *Stops stage movement* at any time. 3. *Cancels the click* and drag function.
Tab	*Step key* to highlight items in a dialogue box.
Arrows	1. Use to *select between items* in a group when in an edit box. 2. When any quad is active and in focus, the stage can be moved approximately 80% of the field of view in any direction by clicking on the appropriate **Arrow key** on the keyboard (or 50% with the **Shift** button pressed simultaneusly).
Alt	When pressed at the same time as an underlined character in the menu bar items reveals the pull-down menu in the active application. (For example, pressing **ALT + M** at the same time brings up the Magnification pull-down menu.)
Alt + Tab	Use these keys to *switch over the resident applications*. This starts from the last used one, continue to press the **TAB** key (while holding down the **ALT** key) and applications are shown one by one. Releasing the ALT key at any time brings application just listed active again.
Ctrl + (Shift+) Tab	Use these keys to *switch over the next / previous quad* and make it in focus.
Alt + F4	*Exit application software* which is active, shut down Windows operating system.
Del	*Deletes* an item in an edit box (a selection or a sign).
Ctrl + C	*Copy* to clipboard
Ctrl + V	*Paste* from clipboard
Ctrl + X	*Cut* to clipboard

TABLE 4-6 FUNCTION AND SPECIFIC KEY SHORT-CUTS

Key (+ Key)	Function
F1	On-Line Documentation (only switches ON)
F2	Photo
F3	Toggle Videoscope
Shift + F3	Home Stage
F5	Toggle Quad Screen / Full Screen
Shift + F5	Toggle Center Cross
F6	Toggle Pause / Unpause
Shift + F6	Toggle Alignment rectangle
F7	Toggle Reduced area on / off
F9	Auto Contrast and Brightness
F11	Auto Focus
F12	Toggle Compucentric Rotation.
Shift + F12	Toggle Scan Rotation
Ctrl + 0 - number	Centers X and Y stage axes to (0,0)
Ctrl + F	Sets FWD to 15 mm
Ctrl + O - letter	Preferences dialogue
Ctrl + P	Prints to selected device
Ctrl + S	Save
Ctrl + B	Beam Blank
Ctrl + I	Stage Tilt 52°
Ctrl + E	Stage Tilt 0°
Tab	Steps between controls
Ctrl + Tab	Steps between quads
+	Increases magnification
-	Decreases magnification
*	Rounds off magnification to nearest rounded number.
(Shift +) Arrows	Move (50%) 80% of viewed field in the direction of the arrow.

5 OPERATIONS

OVERVIEW

This chapter describes how to use the Microscope system from a task-oriented point of view. The following subjects are covered:

- Specimen Preparation and Handling
- Obtaining an Image
- Optimising an Image
- Detector types and usages
- X-ray analysis for different Vacuum Modes
- Selecting Beam conditions
- Obtaining an onscreen image
- Capturing and Handling single images
- Saving Multiple Images (Recording Movies)
- Patterning
- Milling Procedure
- Measurement and Annotation Functions
- Setting Preferences

Caution!
These procedures assume you are familiar with the xT microscope server and xT microscope Control software described in Chapter 4 “Software Control”, which are necessary to start and operate the Quanta 3D microscope.

Specimen Preparation and Handling

The specimen material for **HiVac mode** must be able to withstand a high vacuum environment (without outgassing) and the bombardment of electrons. It must be clean and conductive. Oil and dust may contaminate the chamber environment, which could hinder or even prevent evacuation to the level needed for HiVac operation.

Note:
Always wear lint- and powder-free clean room gloves when reaching into the specimen chamber to minimise oils, dust, or other contaminants left inside the chamber.

NEEDED ITEMS

- Class 100 clean-room gloves
- Specimen stubs and conductive adhesive material
- Tools: tweezers, 1.5 mm hex wrench, screwdriver
- Prepared or natural specimen

NATURAL SPECIMEN

If no coating is desired the **LowVac Mode** can be used to stabilise the specimen for observation. This mode is useful if there is a suspicion that a coating might alter the specimen.
If the specimen contains any volatile components, such as water or oil, and therefore will not withstand coating, then the **ESEM** mode can be utilised with the correct environment gas and pressure to allow observation of the specimen in its natural state.

COATED SPECIMEN

If the specimen is nonconductive (plastic, fibre, polymer or other substance with an electrical resistance greater than 10^{10} ohms) the specimen may be coated with a 1–5 nm layer of metal (Platinum/ Palladium Pt/Pd, Titanium Ti etc). This conductive layer reduces beam instability due to sample charging and improves image quality. For succesful imaging, rough surfaced specimens must be evenly coated from every direction.

Biological, cloth and powder specimens may require carbon or other conductive painting on portions of the specimen that are hard to coat.

Coating reduces beam penetration and makes the image sharper. It may mask elements of interest for X-ray analysis (thus the use of carbon for geological and biological specimens).

For more information on specific preparation techniques, see *Scanning Electron Microscopy and X-Ray Microanalysis, 2nd ed.* by Joseph Goldstein et al., Plenum Press, New York, 1992.

MOUNTING THE SPECIMEN TO THE HOLDER

Wafers and PGA devices have individual sample-mounting procedures. If you are using a wafer piece or other sample, attach the specimen to the specimen holder using any suitable SEM vacuum-quality adhesive, preferably carbon paint. The specimen must be

electrically grounded to the sample holder to minimize specimen charging. If you are using a vice mechanism or double-sided tape, make sure the specimen is conductively attached to the holder.

Note:
The sample holder is not directly grounded to the chamber ground because it is connected to the BNC feed on the chamber door. This is to allow measurement of sample current.

Maximum Sample Dimensions

The Quanta 3D can accommodate samples with maximum dimensions 150 x 100 x 25 mm to achieve full stage movements.

Caution!
Store samples and sample holders in a dry nitrogen storage cabinet. Dust on samples can get drawn into the electron column, degrading imaging and requiring an FEI Customer Service call to correct the problem.

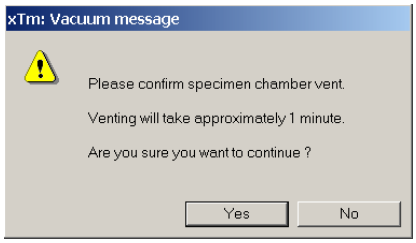
INSERTING / EXCHANGING A SPECIMEN

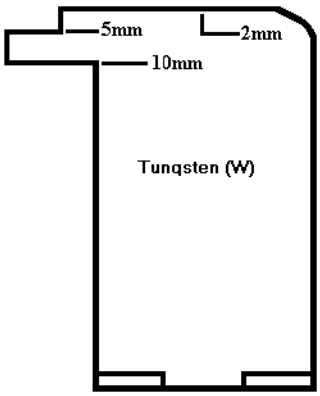
It is assumed, that the microscope is in the Full operation state (see Chapter 3).

Inserting a specimen requires the specimen chamber to be at atmospheric pressure. If the high voltage is on when starting to vent the specimen chamber, the vent condition is interlocked to switch off various voltage supplies before actual venting occurs.

TABLE 5-1 INSERTING A SPECIMEN

Step	Action
1.	Click off the **Beam On** button on the Beam Control page. Go to the **Navigation** page, unlock all stage conditions if necessary. In the **Vacuum** module found on the **Start-up** or **Work** page click on the **Vent** button. The confirmation dialogue appears. After a High Voltage switch off cycle, the vacuum system will switch off the pumps and open / close the appropriate valves to vent the system. After a specified venting time the venting valve will close.
2.	When vented, open the specimen chamber and, using lint-free gloves or tweezers, place a specimen into the specimen holder. Secure the specimen stub with an appropriate hex-wrench unless a spring-clip holder has been used.
3.	Install any additional detector if it is not already done (follow the procedure described below in this chapter).
4.	Set the stage to its lowest position. Check and if necessary adjust the X, Y, Z, Rotation or Tilt before closing the chamber door. If the sample height is higher then it was for a previous sample, turn down the mechanical Z to suit the Adjuster Tool.
5.	Close the door select the vacuum mode (see Chapter 3) and pump the system down by clicking on the pump button on the **Beam Control** page.


xTm: Vacuum message
Please confirm specimen chamber vent.
Venting will take approximately 1 minute.
Are you sure you want to continue ?
Yes
No



Obtaining an Image

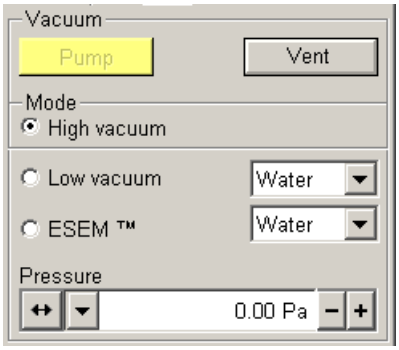
OPERATION PRE-CHECK

To ensure correct operation in any Vacuum mode, check the following list before continuing. After obtaining a preliminary image, you can then experiment with your settings.

TABLE 5-2 QUANTA 3D SETUP CONDITIONS

Adjustment	E-Beam Settting	Ion-Beam Setting
kV (Accelerating Voltage)	Select kV relative to specimen type: - low kV for surface imaging, beam-sensitive samples and slightly charging samples - high kV for conductors, high resolution, compositional info (BSE, X-ray) For example: - biological sample HV = (1–10) kV - metal sample HV = (10–20) kV	30 kV for imaging, milling, depositing 5 kV for cleaning 5–10 kV for large field of view
Vacuum mode	**HiVac:** conductive samples LowVac: nonconductive, mixed or dirty samples **ESEM:** wet samples (use H_2O gas medium)	Only HiVac mode can be used.
Spotsize (for imaging)	**HiVac** and **LowVac:** 3 or 4 **ESEM:** 4 or 5	100 pA at 30 kV
Scan rate	**HiVac:** fast (dwell time 0.1 µs) **LowVac** and **ESEM:** slow (dwell time 0.5 µs)	Fast scan
Free Working Distance (FWD)	Set the highest specimen point to approximately 15 mm. (yellow mark in Optical Beam Quad) and press Ctrl + F (set FWD to 15 mm function).	Set into eucentric position and tilt 52º (see **Eucetric Height** in Chapter 7 “Operations”)
Eucentric Height	15 mm	30 mm
Magnification	Set to lowest – from 100x to 200x	Set to lowest – from 100x to 200x
Standard Detector	**HiVac:** ETD (SED) + SSD BSE optional **LowVac:** LFD + SSD BSE **ESEM:** GSED + GBSD optional	HiVac: ETD (SED)
Filtering	**HiVac:** live **LowVac** and **ESEM:** live	**HiVac:** live **LowVac** and **ESEM:** live
Contrast and Brightness	With contrast at minimum value adjust brightness to just show a change in intensity to the screen. Increase the contrast to produce a reasonable image on screen. Increases in brightness and decreases in contrast produce softer images. The reverse produces sharper images.	See E-beam Setting column.

SELECTING VACUUM MODES



When a specimen and appropriate detector(s) are inserted correctly, close the specimen chamber door and follow the instructions:

A) High Vacuum

This is the conventional operating mode associated with all scanning electron microscopes. The high vacuum condition is achieved throughout the column and specimen chamber.

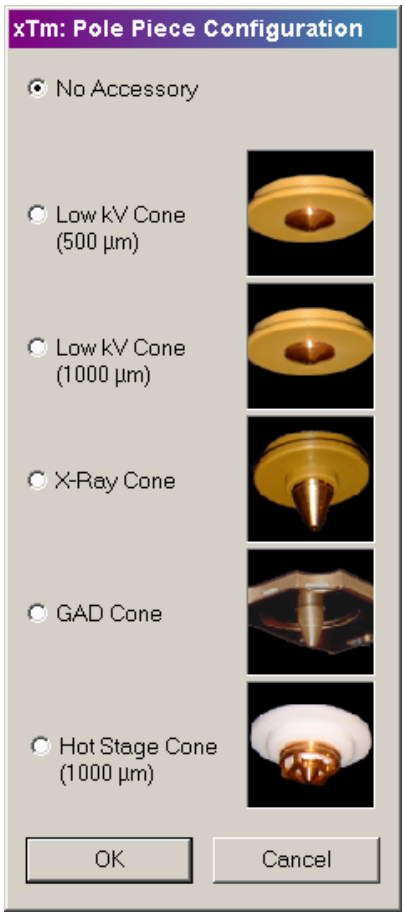
B) Low Vacuum and ESEM Modes

The SEM modes (**LowVac** or **ESEM**) are used to image non-conductive and non-coated specimens. Which one of these is used depends on whether the sample just needs charge control (non-conductive) or it is to be imaged with the Peltier stage (ESEM is normally reserved for Peltier cold stage work). Certain detectors are optimized for these modes: the LFD corresponds to LowVac, and the GSED (GBSD optional) corresponds to ESEM.

In either of these modes, the gun and column sections are under high vacuum, whereas in the specimen chamber the pressure ranges from 0.1 to 20 Torr (10 to 2600 Pa).

Either mode can use the imaging gas selected in the **Mode** drop down box:

- water vapour from a built-in water reservoir located in the back part of the microscope console,
- auxiliary gas which is supplied by the user and is connected to a gas inlet provided for this purpose on the back of the console.

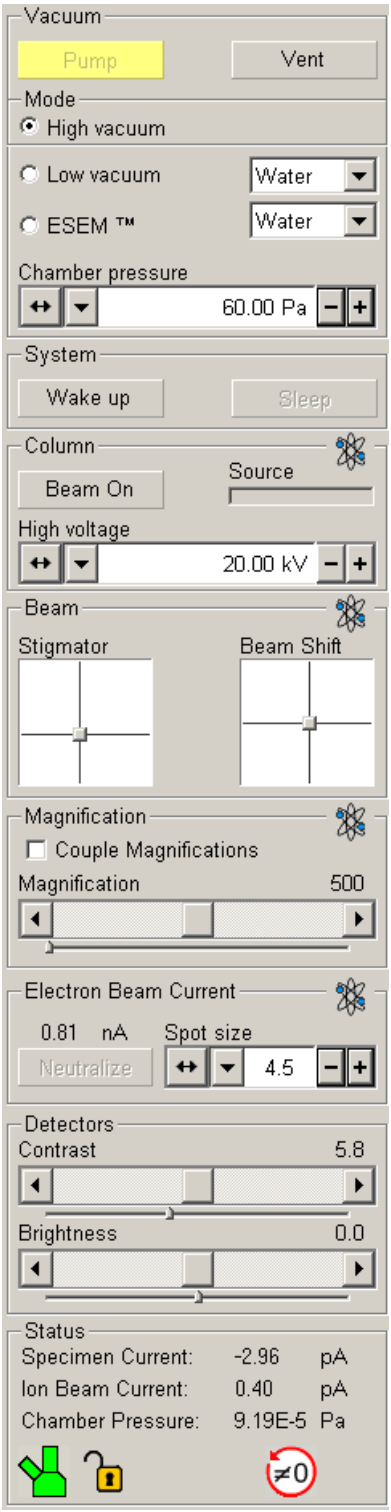


The microscope also provides automatic sequencing for purging the specimen chamber according to the settings of **Purge mode** in the **Preferences... / ESEM** tab (see the end of this chapter). This sequence purges any remaining room air out of the chamber during "pump" or during gas change it replaces the current chamber gas with a new gas determined by the target operating mode.

TABLE 5-3 SELECTING VACUUM MODE

Step	Action
1.	In **Vacuum / Mode** module, select the **High Vacuum / Low Vacuum / ESEM** radio button.
2.	Select the appropriate gas from the dropdown list.
3.	In the **Vacuum** module click on the **Pump** button. The target pressure that the system will pump to is specified in the **Pressure** text box at the bottom of the **Mode** module.
4.	Under normal operation, the system will know the **PLA size** for the detector installed. This will allow the system to set automatic pressure range limits for the aperture installed, thus avoiding vacuum errors when setting chamber pressure. In some cases the user will be prompted for the PLA size. Select "No Accessory" for the **LFD,** or the appropriate cone, if installed.
5.	Wait for the vacuum status **Pumped**, represented in the **Status** module at the base of the page by green icon.

OBTAINING AN IMAGE ON SCREEN



The following assumes that the Ion source emission is ready.

TABLE 5-4 IMAGING PROCEDURE

Step	Action
1.	On the **Beam Control page** for the active beam, click on the **Beam On** button, found in the **Column** module, to ramp up the High Voltage.
2.	Select the detector (see next chapter) and unpause the chosen quad.
3.	Choose the highest specimen point and bring it to the 15 mm Working Distance (yellow line in Optical Beam Quad). Focus the image and run **Link Z to FWD** procedure (see Chapter 4).
4.	Run the **Auto Contrast Brightness** (F9) in the **Tools** menu, or control the contrast and brightness from the detector module found on most pages.
5.	Adjust to a suitable magnification, optimize the image (**contrast and brightness, focus, astigmatism**) – fuller explanation later in this chapter.

Optimising an Image

PRINCIPLES OF SEM IMAGING

All scanning beam microscopes produce images with the same fundamental technique. The primary beam is scanned across the specimen surface in a regular pattern called a raster. Normally, this raster consists of a series of lines in the horizontal (X) axis, shifted slightly from one another in the vertical (Y) axis. The lines are made up of many dwell points and the time of each dwell point can be shortened or prolonged (dwell time). The number of points per line can be increased or decreased as well as the number of effective lines. The result is a picture point (pixel) array. Low or high resolution images can be obtained by manipulating these factors. The larger the pixel array, the higher the resolution on the end image. Simultaneously, a spot of controllable brightness is scanned over the display area of a monitor in the same pattern.

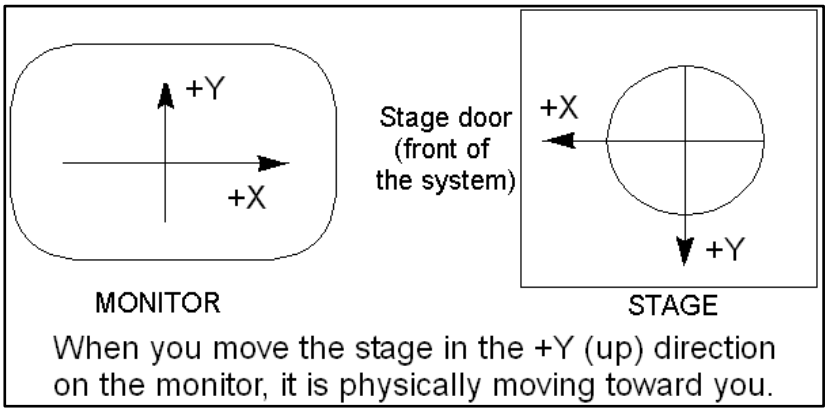
The signal emitted by the sample surface as it is illuminated with the primary beam is collected by the detector, amplified and used to adjust the intensity of the corresponding pixel of the video monitor.

Because of this direct correspondence, the image displayed on the monitor is directly related to the sample surface.

The spot must be scanned across the screen very rapidly so that the human eye sees it as a continuous image and not a moving spot. Because most beam scanning takes place at rates too slow to provide the illusion, the slowly-gathered image is loaded into computer memory. This stored image is displayed at a fast scan rate, but updated only at the beam scan rate.

The raster consists of many (typically one million) individual locations (pixels) that the beam visits. As the beam is scanned, the signal emitted by the sample at each beam position is measured and stored in the appropriate digital memory location. At any time after the beam scan, the computer can access the data and process it to change its properties, or use it to generate a display.

FIGURE 5-1 RELATION BETWEEN VIEWED IMAGE AND STAGE

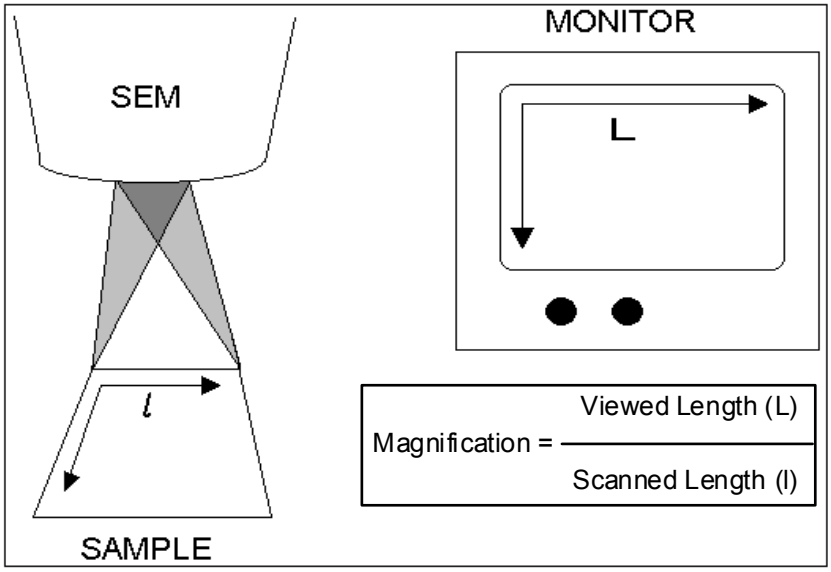


This drawing is also an indication of reference for the wafer map.

MAGNIFICATION

Magnification is calculated with reference to the relationship of displayed image dimension (L) divided by the sample scanned dimension (l) (see Figure 5-2).

FIGURE 5-2 MONITOR IMAGE AND SCANNED SAMPLE

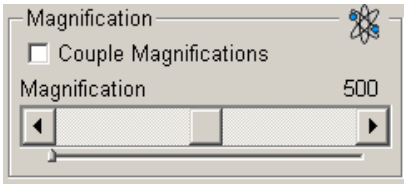


If the size of the raster on the sample is made smaller while the raster on the monitor remains constant in size, the magnification of the image increases. At low magnification, you see a large field of view. At medium magnification, you see a portion of the original scanned area. At high magnification, you are zoomed in on only a small portion of the original total scanned area.

The Quanta 3D supports two viewing sizes: **Quad mode** and **Full screen**. Magnification is always adjusted in the databar for the current display, thus an image at 500x in Quad mode is 1000x in full screen as its size has doubled.

Changing Magnification

- The **Toolbar List Box** is used to select from a list of predefined values. If the current value is in the list, it is indicated with a coloured background. Click on the text box and the list of magnifications rolls down. Click on the required magnification, which appears in the text box. The list box then automatically closes. During live imaging this procedure results in immediate magnification change.



- The **Magnification module** enables the user to set the **Magnification** by means of the continuous adjuster and then couple it by ticking the **Couple Magnifications** check box with the other Beam magnification. The icon indicates the beam in active operation at the right side of the module.This feature can also be accessed via the **Beam** menu as **Couple Magnification**.
- **Keyboard control (+ / - / *):**
  The plus key (+) increases the magnification 2x.
  The minus key (-) decrease the magnification 2x.
  The star (*) key rounds off the magnification value (e.g. 10 063x becomes 10 000x).
- **Mouse wheel control:** Coarse / fine control can be operated by holding the Ctrl / Shift keyboard key and moving the mouse wheel up / down to increase / decrease the magnification.

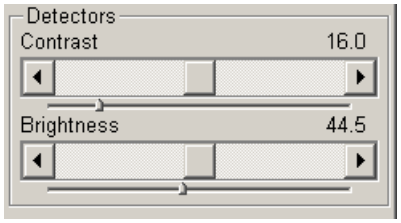
- **Selected Area Zooming In / Out** is a quick way of zooming in or out on an area of interest. The function is activated by left mouse clicking on the image and dragging to make a dotted box over the area of interest. The cursor changes to a magnifying glass with + sign in the bottom right corner of the selected area. Once the left mouse button is released the selected area increases in magnification to fill the quad or full screen. The longest side of the selected area drawn has priority for the end magnification.

  Using Shift + the left mouse button reverses the zoom effect by reducing the quad or full screen area down to fit the selected area drawn, the longest side having priority for the end magnification. In this case the cursor changes to a magnifying glass with a - sign in the bottom right corner in the dragged area. The escape button cancels the operation at any time.

SCAN SPEED AND FILTERING

To produce the highest quality image at low beam currents, use slow scan rates (large dwell time). If an image is noisy with No Filtering selected, decreasing the scan speed improves the image quality by increasing the signal-to-noise ratio. You can also improve image quality by using the **Average** or **Integrate** functions (See Chapter 4).

CONTRAST AND BRIGHTNESS



The contrast and brightness settings can be set manually either by using the MUI or by adjusting the contrast and brightness controls in the **Detectors** module found on several pages (See Chapter 4).

TABLE 5-5 CORRECTING C & B

Step	Action
1.	Select a medium speed scan in an active Quad.
2.	Reduce the contrast to zero and adjust the brightness to a level so that the last gray level can be seen, by eye, before the screen goes black.
3.	Increase the contrast so that the signal level shows an image.
4.	If necessary, adjust the brightness level to improve the image.

Using Videoscope (F3)

The contrast and brightness settings in **Videoscope** mode can be adjusted to optimise the image to give the best range of greyscale for viewing or output as a stored image.

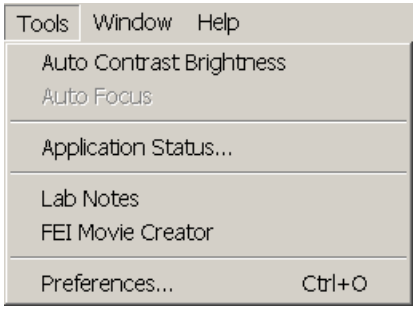
The Quad or full screen displays an overlay of two separated horizontal lines indicating white (top line) and Black (bottom line). A monitor waveform is displayed between or overlapping the two lines. Magnitude and central position of the waveform represents contrast and brightness respectively. Overlapping in any way means that the signal level is clipping in either black or white and should be avoided in normal imaging. Controlling the waveform exactly between the two lines for the entire scanned image indicates full greyscale capability in that image. For harder contrast conditions (for instance, in BSE images, when more black and white is sometimes needed), the amplitude of the waveform can be made to overshoot the two lines to

give this effect. The shortening of the amplitude between the two line decreases the contrast accordingly.

TABLE 5-6 CORRECTING C & B USING VIDEOSCOPE

Step	Action
1.	Select a slow scan in an active quad
2.	Click on the Videoscope button on the toolbar.
3.	Reduce the contrast to zero and adjust the brightness level to the lower dashed line (black).
4.	Increase the contrast so that the signal level just clips the upper dashed line (white).
5.	If necessary, adjust the brightness level once more so that the average signal level roughly in the middle.
6.	The high and low peaks should just clip the dashed lines.

Enhanced Image on the **Processing** page can be used to adjust the LUT, including Gamma control. This can be useful for low signal conditions or odd imaging requirements. Results affect the videoscope display.



Auto Contrast Brightness Function

Auto Contrast Brightness (ACB) can be activated by pressing the ACB icon button on the toolbar or the item in the Tools menu. The system sets the contrast and brightness levels to suit the sample so that the majority of grey levels are displayed (See Chapter 4).

FOCUSING

The easiest way to focus is to find a feature of interest with distinct edges on a specimen. Use a combination of contrast, brightness, magnification, and focus adjustments to maximize the image quality.

TABLE 5-7 CORRECTING FOCUS

Step	Action
1.	Press CTRL simultaneously with the right mouse button while moving the mouse from side to side in the active quad to focus the image, then release.
2.	The focus cursor, which is a double-ended arrow, appears. Move the focus cursor from side to side until the image is sharp.
3.	When engaged, the focus cursor is active over the whole screen but will not interfere with other controls
4.	Move the specimen to a desired area with the X and Y stage controls or double-click with the right mouse button on the desired area and refocus until the image is sharp.
5.	If this is the first time focusing the new specimen, then click on the Z to FWD icon button on the toolbar to set the Z value on the **Navigation** Page equal to the actual free working distance.

To avoid scanning too long with the ion beam and milling away the sample before you take the final image, move away from the feature of interest with the X and Y stage controls, and focus until the image is sharp on a adjacent area.

Focusing at 2x to 3x the necessary magnification for the final result makes the lower magnification sharper. For example, for high resolution output, set the magnification level at 2000x and focus at 4000x to 8000x.

Note:
Particularly in case of ion imaging you must be aware of the fact that higher magnification increases the risk of damage to the sample.

Focusing with the MUI

Use **coarse** and **fine** focus knobs to focus the image. The image immediately responds to the MUI without a cursor on-screen.

Using Reduced area (F7)

The smaller area appears in the middle of the screen. This can be used as a Focus aid as the scan refreshes faster in the smaller area (See Chapter 4).

Auto Focus Function

This function can be activated by pressing the Auto focus icon button on the toolbar or the item in the Tools menu. The system attempts to correct the focus independent of the actual focus setting (see Chapter 4).

CORRECTING ASTIGMATISM

You need to correct astigmatism of the image when you change apertures, samples or working distance conditions. Astigmatism in the image is usually only visible at higher magnifications (3000x or more). If astigmatism is present, a directional distortion change of 90° between the two out-of-focus conditions is observed.

TABLE 5-8 CORRECTING ASTIGMATISM USING THE MOUSE

Step	Action
1.	Focus the image as well as possible using the mouse.
2.	Bring the image just slightly out of focus. The image will appear to become sharper in one direction whereas in perpendicular direction image distortion increases (bluring or stretching of the image).
3.	Defocus in the other direction to observe a different astigmatic distortion.
4.	Focus to the midpoint between the two distortions.
5.	Press shift and hold the right mouse button down while in the active quad. This results in a 4 arrowed cross appearing on the screen with the cursor position at its center. Still holding the right mouse button down, move the cursor around the screen to achieve maximum astigmatism correction (when the image is sharpest).
6.	When you are satisfied with the image, release the right mouse button.

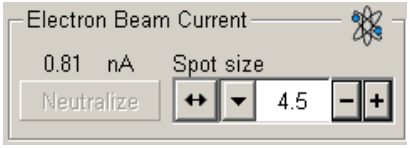
If astigmatism is severe and the cross is close to the edge of the screen when nearing correction, release the right mouse button, and reposition the cross in the center of the screen. Then repeat the procedure above to perform further astigmatism correction. You can use reduced area advantageously in a similar way as was described for focusing.

If stigmation cannot be corrected, there may be some other reason (usually the insert apperture is dirty – see Chapter 8 “Maintenance” for cleaning instructions), the magnification may be too high for the beam spotsize (see below) or the sample is charging (apply conductive layer or use ESEM mode).

TABLE 5-9 CORRECTING ASTIGMATISM USING THE MUI

Step	Action
1.	Using the MUI **Focus** knobs, bring the image just slightly out of focus in one direction to see any astigmatic distortion.
2.	Defocus in the other direction to observe a different astigmatic distortion.
3.	Bring the focus to the midpoint between the two distortions.
4.	Adjust image sharpness with the stigmator **X** and **Y** knobs until the best image is achieved. The computer beeps when the stigmation limits are reached.
5.	Repeat steps 1–4 as necessary.

BEAM SPOTSIZE



The actual focused area of the single beam on the sample at any point is referred to as spotsize. **Spotsize** has assigned numbers that range from 1 to 10 with values corresponding to beam current. For each ascending high voltage, from 200V to 30kV, the range of beam currents increases in value accordingly. There are 15 available beam currents for the Electron Beam and 12 for the Ion Beam. These preset values can be found in the **Toolbar** dropdown list.

TABLE 5-10 SPOTSIZES AND RECOMMENDATION OF THEIR USE

Spotsize	Best Use
1, 2	Very high resolution (mag >50 000x)
3, 4, 5	Standard imaging, SE, BSE, LFD, GSED
6, 7	BSE, CL, X-ray analysis, EBSP
8, 9, 10	Charge neutralization

Adjusting Spotsize for Imaging

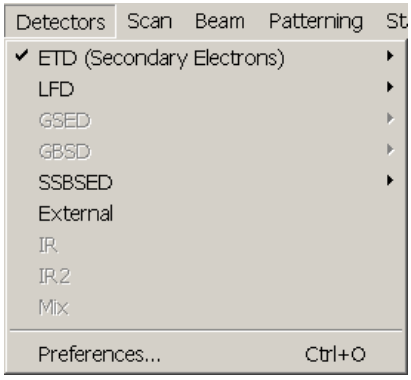
Spotsize is considered to be close to ideal when the edges of the beam just touch when adjacent lines are scanned. If the spotsize is too large, overlaps occur and the image appears out of focus. If the diameter is too small, electronic noise appears in the image.

Deciding which spotsize is correct for a particular magnification can be determined when you achieve good focus and astigmatism correction easily at the chosen magnification.

Use the focus control with the right mouse button to correct the sharpness of the image. Focusing at 2x–3x the magnification needed for the final result makes the lower magnification sharper. For example, set capture magnification to 2000x, and focus with magnification at 4000x–8000x.

When you change spotsize, readjustment of **Contrast** and / or **Brightness** in the **Detector** module may be necessary to refresh the image onscreen. An alternate approach is to press the **Auto Contrast and Brightness** button found on the toolbar.

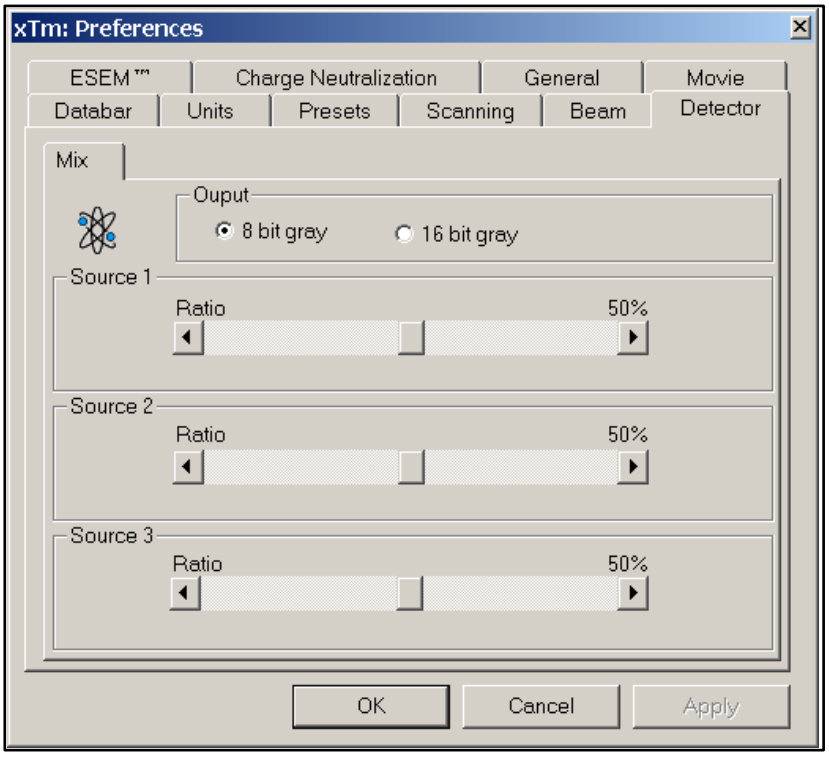
MIXING LIVE IMAGES FROM MORE DETECTORS



If you choose different detectors (if they are installed) of the same beam for Quads 1 and 2, you can choose the **Mix** option for Quad 3. Similarly it is possible to use MIX option for Quad 4 when mixing signals from Quads 1, 2 and 3.

Clicking on **Preferences...** displays a dialogue that allows the user to choose a percentage of one detector to mix with another.

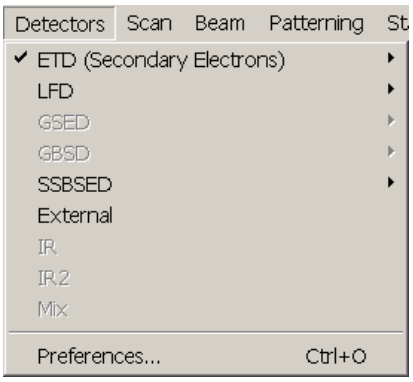
FIGURE 5-3 PREFERENCES... DIALOGUE FOR DETECTORS SIGNAL MIXING



- **Output** radio button sets the depth of resulting image shades to 8 or 16 bit.
- **Source 1...3:** The positioning of the adjusters varies the amount of input from particular detector in the range from 0% to +100%.

Note:
Because only the raw image is used to mix, any setting made in the Enhance Image module are not applied before mixing. It is possible to use these enhancement for the mixed image in Quad 3 or 4.

Detector Types and Usage



The **Detectors** pull-down menu shows the detectors installed on your system. Select the detector to be used for imaging. When you select a detector, the last set C & B values for the chosen detector and mode are set. Availability of detectors (full colour detector name in the menu) depends on vacuum state and chosen beam. The system always reverts to the last detector used for that beam.

Note:
If any detector which is not compatible with a vacuum mode and / or beam is selected, the imaging quad cannot be unpaused.

TABLE 5-11 STANDARD IMAGING DETECTORS

Detector Type	Name	Vacuum Mode	Detection Mode
Everhard-Thornley detector	ETD	High Vacuum any	Secondary electron Back-scattered electron
Large Field	LFD	Low Vacuum	Secondary electron
Gaseous Secondary Electron	GSED	ESEM	Secondary electron
Gaseous Backscattered	GBSD	ESEM	Secondary electron Back-scattered electron
Solid State Backscattered Electron	SSBSD	any	Back-scattered electron
Photomultiplayer	PMD	any	Back-scattered electron Catodoluminescence
External (third party)	External	any	

CHANGING DETECTORS OR CUSTOM MODE

All detectors, when active, show real-time operation except while patterning is in operation. Therefore, when changing detectors or changing conditions, such as in the Preferences dialog for the Custom modes, the active detector(s) will show the changes in real-time.

Electron Beam

Ion Beam

Beam indicators

A similar dialog appears for each custom detector. Depending on the beam in use at the time the dialog opens, an indicator icon is presented in the dialog.

On hold changes when Patterning

During the patterning process the Detector Menu is still in use, but setting changes will not become active until Patterning has stopped or has been interrupted. The Custom mode and Preferences are still available. A typical circumstances under which changes may need to be made to a detector while patterning is when Snapshot or Grab Frame will be used during a patterning session. These facilities can be set up in advance. When patterning has stopped, the last scan detector and scan conditions will be active.

Preferences...

Clicking on **Preferences...** from the Detector Menu opens the **Detector** Tab, which shows the specific detector mode that is active in the Detector menu for the quad in use. Detectors that have a custom mode will have a Preferences dialog for adjustment.

STANDARD IMAGING DETECTORS

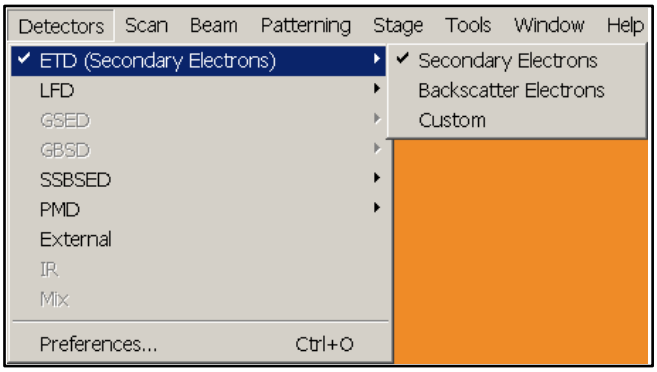
You can choose from two default modes and one custom mode for ETD detector in the Detectors menu. A tick mark next to the entry indicates it is active. Placing the mouse cursor over the small black arrow on the right of the menu activates a menu extension with the choice of detection mode.

Everhart Thornley Detector (ETD)

is a Secondary Electron **(SE)** or BSE detector. It is a scintillator type detector monitoring secondary or back-stcattered electrons generated by the primary beam interaction with the sample to produce an image. It is mounted in the chamber above and to one side of the sample.

When the **ETD** is activated, contrast and brightness adjusters control the ETD parameters. The ETD high voltages (scintillator, grid) are switched off during venting of the specimen chamber or during vacuum mode change. This detector is permanently fitted to the chamber.

FIGURE 5-4 ETD DETECTION CHOICES



Preferences for the ETD

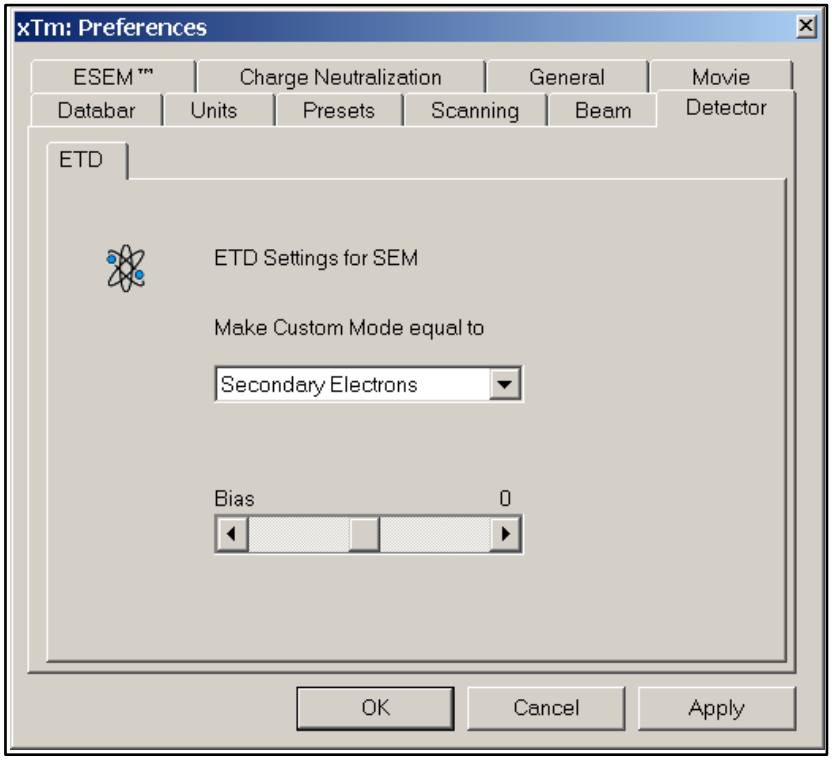
The **Detector Configuration** dialogue box contains an adjuster to control grid bias voltage. When grid bias is negative, secondary electrons are repelled from the **ETD** detector and only back-scattered electrons are detected. Use a range of -25 to -150 V to obtain back-scattered electrons. The range for grid bias voltage is from -150 V to +250 V. The normal operating setting for imaging is +250 V. These settings are ordinarily preset at the factory but you may need to adjust them for optimum imaging on individual specimens.

ETD Custom settings

A preferences Tab will automatically display when you choose custom mode for ETD. The Detector Preferences dialog box contains adjuster(s) to vary the custom mode of the detector. When grid bias is negative, secondary electrons are repelled from the ETD detector and only back-scattered electrons are detected. The biasing capability is from -150V for only backscattered electrons to +250V for secondary collection.

Selecting preferences for the ETD Custom mode will set those conditions in the ETD menu as the Custom mode. Clicking **OK** will finalise the preference and **Cancel** will return the settings to the previous values. All changes made are visualised in real-time (except while patterning), and the detector responds immediately, therefore conditions can be tested before clicking the OK button.

FIGURE 5-5 ETD CONFIGURATION DIALOGUE



Gaseous Secondary Electron Detector (GSED)

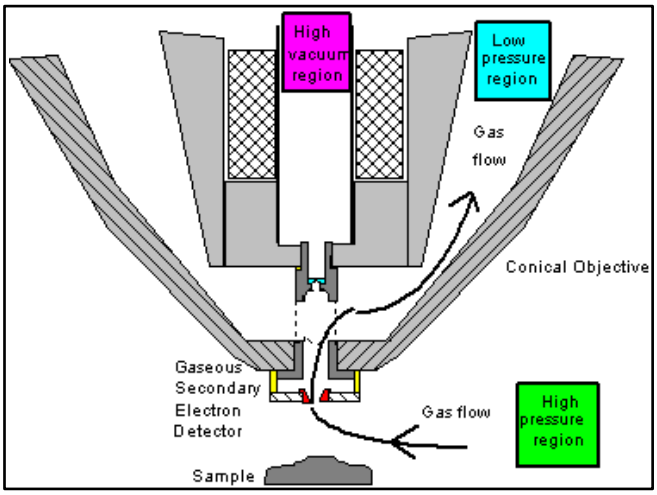
The GSED is integrated into a flexible PC board and plugs into the signal connector under the ion column. The standard GSED contains a 500 µm aperture, allowing 20 Torr (2600 Pa) maximum chamber pressure. It is a standard detector with all ESEM systems. A detector with a larger 1000 µm aperture is also available as an option (must be ordered as a special request), the upper pressure limit of which is about 5 Torr (670 Pa).

FIGURE 5-6 GASEOUS SE DETECTOR (GSED)

This is used for general wet imaging and for high pressure imaging with auxilliary gasses. As it is optimized for higher pressures, it has a small opening to restrict gas flow which also reduces the field of view. The lower magnification range is about 240x at 7 mm working distance. The

overall image consists of a very pure secondary electron signal with very little back-scattered electron signal component, due to the detector design and chamber geometry. This pure secondary signal makes this detector best suited for resolution imaging. The field of view is less than the LFD at the lowest magnification.

FIGURE 5-7 STANDARD GSED CONFIGURATION

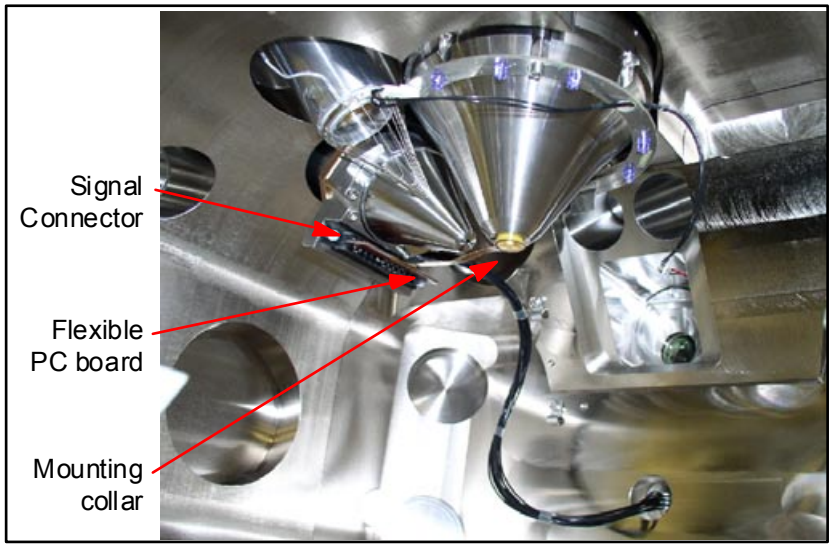


Installing the GSED

With your gloved right hand, grasp the detector by the rigid connector end. Hold it with the detector head facing back towards you, and the yellow Torlon ring facing up. Insert the detector (gold fingers facing forward) into the connector located under the ion column. This is made easier by inserting the right side of the detector into the visible portion of the connector, then rotating the detector into position. A keyed position in the connector will prevent the user from inserting the detector up-side-down.

Next, place the yellow Torlon ring of the detector head under the lens insert and press the detector head up onto the insert. This requires little force and can be done with one finger. The yellow Torlon seal should be fully in contact with the lens.

FIGURE 5-8 THE GSED INSTALLED IN THE SEM



Removing the GSED

C a u t i o n !

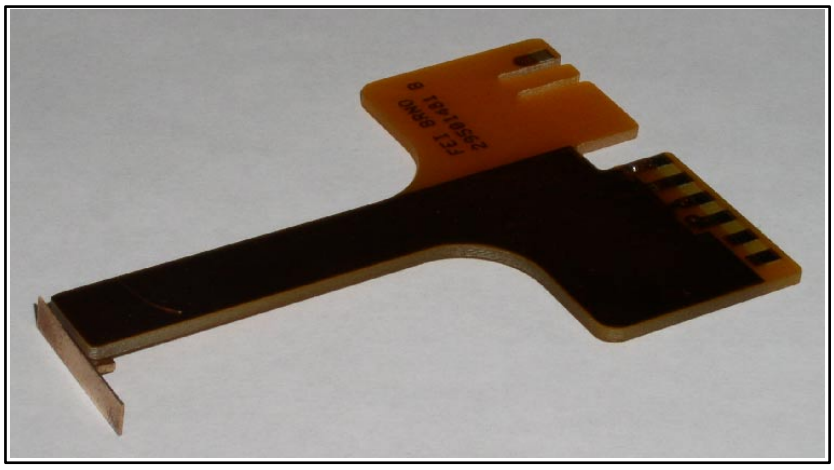
DO NOT pull the detector from the connector first, intending to then pull down to remove the detector head from the insert. This will damage the detector. To prevent damaging the detector, it is important to remove it as described here.

To remove the GSED, first remove the detector head from the lens insert. Do this by catching a fingernail or thumbnail (of the gloved hand) on the FRONT of the yellow Torlon ring and pull down. A shoulder is machined into the Torlon ring which is specifically designed for this purpose. Next, pull the other end of the detector out from the connector.

Large Field Detector (LFD)

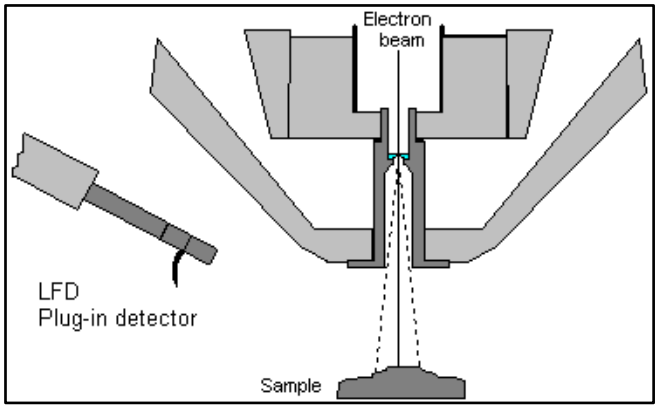
is used in the **LowVac** mode. The LFD is standard on all ESEMs and is used for imaging most samples. This detector is used with the standard insert, at the low pressure range of 0.1 Torr (14 Pa) to about 1.0 Torr (134 Pa). With this detector in place, the field of view is unrestricted and the magnification range will be identical to that of HiVac mode (assuming no other pole-piece accessory is mounted).

FIGURE 5-9 LARGE FIELD DETECTOR (LFD)



The signal from the LFD contains more back-scattered electron information than the GSED signal. The detector is ideal for general imaging; it is also the only secondary gaseous detector that can be used simultaneously with a solid state BSE Detector.

FIGURE 5-10 LARGE FIELD OF VIEW WITH LFD

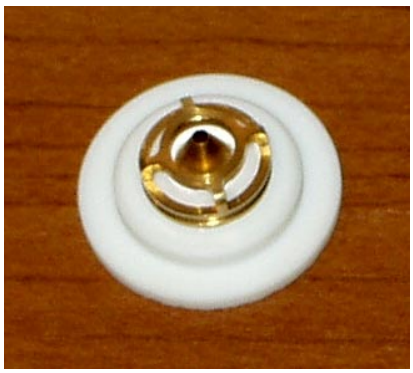


Installing the LFD

The **LFD** plugs into the signal connector behind the conical lens. In some cases the user will be prompted for the PLA size. Select **No Accessory** in the **Pole Piece Configuration** dialogue or appropriate **Cone** if installed. The vacuum system will automatically be limited to the pressure range according to this selection.

Note:
After inserting the LFD, **Purge mode** changes to **Automatic** despite any previous selection. This ensures that the proper chamber environment is achieved and requires the user to remember to set the purge back after a wet experiment. (see Setting **Preferences... / ESEM** tab at the end of this chapter).

PLA CONES



- **Standard Insert** is installed at all times, except when the optional Heating stage is in use. Environmental detectors, such as the GBSD and GSED, and the PLA cones, press onto the insert to form a gas seal. Chamber gas that flows through the detector apertures are pumped out through the holes in the sides of the insert (EC1 area). A gas-restricting aperture is found at the top of the insert. This aperture also acts as a final or objective aperture. The pressure above this aperture is considered to be high vacuum. Any foreign material that accumulates on this aperture will greatly affect the image. If stigmation is not possible to correct, it is usually a sign that this aperture needs to be cleaned or replaced.
- **Low kV PLA** is installed onto the standard insert in case the **LFD** is used for low vacuum and low kV imaging (i.e. below 5 kV) to reduce beam loss in the gas. This PLA is used when imaging at shorter working distances (< 9 mm). It contains a 500 µm aperture, which restricts the lower magnification limit and allows a maximum chamber pressure of 20 Torr (2600 Pa).
- **Hot Stage Cone** is used with the heating stage in combination with the hook wire or LFD. It has a 1000 µm PLA and can be used without the hot stage when beam protection is desired with a larger field of view. This is not a standard item and can be ordered.
  The **X-ray PLA cone** is used for EDX analysis (see below) at larger working distances (> 9 mm).

DISCHARGES BETWEEN THE GASEOUS DETECTORS AND THE SAMPLE

The contrast control adjusts the voltage on the underside of the GSED; contrast of 100% is approximately 550V (with the LFD it is 750V). Excessive voltage may cause a “breakdown” between the detector (+550V) and the sample (at ground), chamber, pole-piece etc. This could damage the sample (but will not damage the GSED). This condition is indicated by white flashes or streaks across the image window, and on some systems a large discharge may make the system unstable or cause the chamber to vent and switch off the HV. There are several factors that could cause detector voltage breakdown:

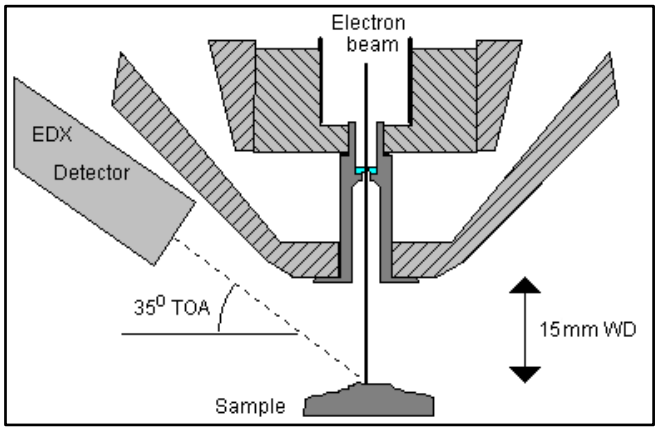
- Contrast (voltage) set too high
- Sample is too close to the detector
- Gas pressure is too low
- Air in the chamber (water vapour purge cycle not complete)
- Sample is not grounded to the stage, or the stage is not fully grounded (BNC plug not connected).

X-ray Analysis for different Vacuum Modes

HIGH VACUUM

HiVac operation gives the most accurate X-ray results, but the sample must be electrically conducting.

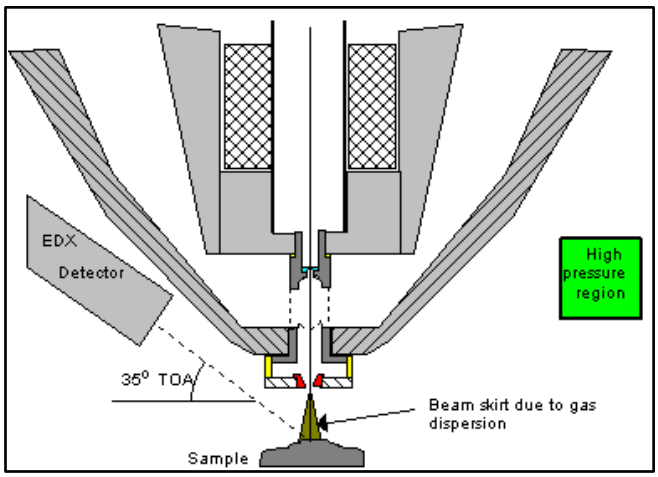
FIGURE 5-11 X-RAY IMAGING IN HIVAC MODE



ESEM WITH THE GSED

The ESEM mode of operation allows observation of electrically insulating samples, but care must be taken when using this mode to collect X-ray results.

FIGURE 5-12 X-RAY IMAGING WITH THE GSED



Some of the electrons are deflected due to interaction with the chamber gas. The deflected electrons form a “skirt” around the main beam. The skirt electrons will hit the sample at points that are remote from the area of interest, and generate X-rays from these points.

The number of skirt electrons increases with chamber pressure and the distance that the beam travels through the gas. The effect of these skirt electrons can be minimized by reducing gas pressure, or by shortening the distance between the sample and the final PLA.

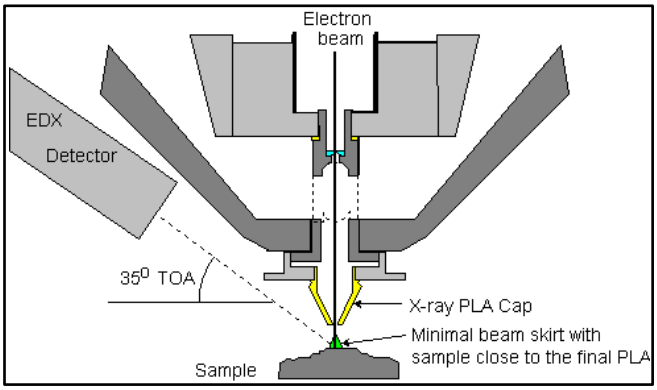
The X-ray detector is designed for the sample to be at 15 mm FWD. This working distance is too long for optimum imaging with a high

pressure detector such as the GSED. For this reason, the ESEM is supplied with a special X-ray PLA which is used in conjunction with the LFD to give the best results.

ESEM WITH LFD AND X-RAY PLA

The following figure shows the lens configuration for X-ray analysis using the X-ray PLA cone. This cone has a 500um aperture and fits over the standard insert. It is used along with the LFD.

FIGURE 5-13 CONFIGURATION FOR THE X-RAY PLA CONE



EDX analysis should be performed at the lowest possible gas pressure, so it should be done with the LFD. Normally, X-ray analysis is performed with a relatively high beam current so that there is enough signal for a good LFD image even at very low gas pressure.

The Hot Stage cone can also be used with the LFD for X-ray analysis and has a field of view twice as large as the X-ray PLA.

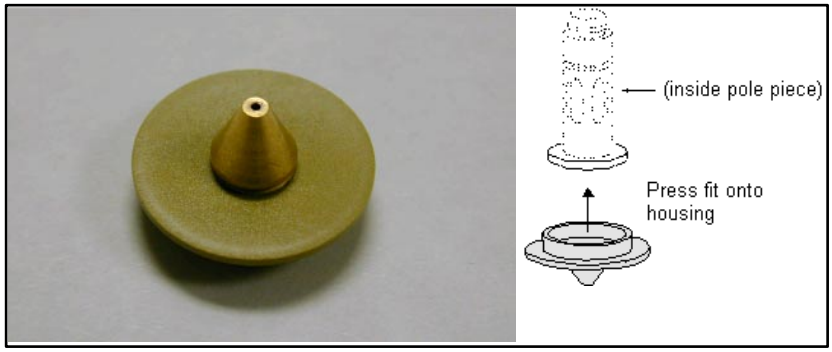
X-ray PLA

The X-ray PLA has a longer working distance profile extending down to 8.5 mm. Samples are imaged at 15 mm working distance, which is the eucentric point of the stage and the collection point of the EDX detector. It is used in conjunction with the LFD.

The longer profile of this cone minimizes the low kV beam dispersion and skirting of the primary beam in the gaseous environment of the chamber, allowing more electrons to interact with the specimen when focused and increasing the signal to noise ratio. The aperture is 500 µm and has the same pressure limits as the standard GSED. When the Pole-Piece Configuration dialogue appears, the 'X-ray Cone' option should be selected.

To fit the X-ray PLA cone, remove any existing detector or PLA cone from the lens insert, then press the X-ray PLA cone into place.

FIGURE 5-14 X-RAY PLA



Selecting Beam Conditions

HIGH VOLTAGE AND BEAM CURRENT

The choice of High Voltages and Beam Currents displayed in the editable dropdown list boxes on the toolbar depends on the type of beam that is active, either Electron or Ion.

The High Voltage and Beam Current are related, any selected HV provides an individual set of beam current values. Changing HV will change the beam current values.

Changing High Voltage

Click on the dropdown arrow to the right of the text box or directly in the text box and the list of voltages will be available. Click on the required voltage and it appears in the text box. The dropdown list automatically closes. If this is done while the beam is on, the change is immediate.

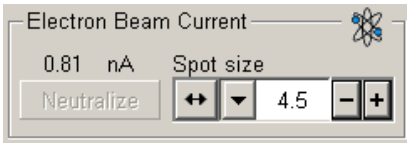
An intermediate value can be entered into the text box for HV and this provides a calculated range of beam current values. Default HV values in the list box can be set from the **Preferences... Beam** tab.

Changing Beam Current

Click on the dropdown arrow to the right of the text box or directly in the text box and the list of currents will be available. Click on the required current and it will appear in the text box. The dropdown list automatically closes. If this is done while the beam is on, the change is immediate.

For the Electron beam, the correct beam current for a particular magnification can be determined when you achieve good focus and astigmatism correction easily.

Choosing the correct Ion beam current is determined by the application. For each Ion beam current a particular beam limiting aperture is used. When increasing the Ion beam current, a larger aperture is applied.



The electron Beam Current can also be chosen using the **Electron Beam Current** module in the **Beam Control** page.

I-BEAM APERTURES

In general, use a smaller aperture for high resolution and a larger one for large scale or faster milling.

TABLE 5-12 SPECIFIC OPTIMAL I-BEAM CURRENTS

Beam Current	Best Use
1 pA	Very high-resolution imaging High aspect ratio holes High-resolution imaging Pt via filling
10 pA	Quick imaging Fast Pt via filling
30 pA **50 pA**	Navigation imaging Milling submicron holes Final clean milling on cross sections
100 pA	Milling micron-sized holes Intermediate / final clean milling on cross sections Short Pt strap deposition
300 pA **500 pA**	Milling micron sized holes Medium Pt strap deposition Intermediate milling on cross sections
1000 pA	Initial rough milling for small cross sections Long Pt strap deposition
3000 pA	Initial rough milling for medium cross sections Longer Pt strap deposition
5000 pA	Initial rough milling for medium-large cross sections Pt probe pad deposition (40 µm x 40 µm)
11500 pA	Initial rough milling for large cross sections Pt bond pad deposition (50 µm x 50 µm)

Capturing and Handling a Single Image

After obtaining a good image quality, the image could be paused and saved. It is possible to save an image using the File menu or using the included xT DOCU database software image saving function (see separate manual), which is the preferred solution. All data should be stored on the support PC rather than the microscope controller to prevent filling the hard drive.

For a detailed description of the following functions see Chapter 4.

SNAPSHOT AND PHOTO BUTTONS

The **Snapshot** icon button is represented as a camera (with a short time dial) on the toolbar. When an image is required at any time (milled position during milling process for instance) one can click on **Snapshot** and a single scan using the predetermined scan settings (see **Preferences.../Scanning** tab) is activated. The image is paused at the end of the scan.

The **Photo (F2)** function in the scan menu allows a preset high-quality, high-resolution image to be taken. This feature, like Snapshot, can also be preset in **Preferences.../Scanning** tab, where it is represented as a camera (with a long time dial). Slower scan rates will be most generally be used with this image-capture method.

PAUSE BUTTON

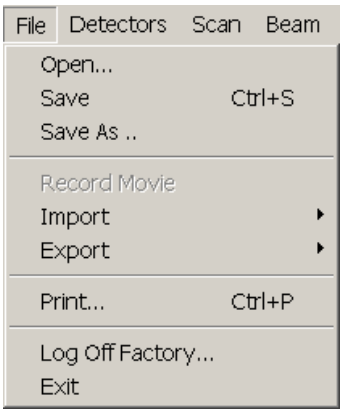
Clicking on Pause with the left mouse button stops scanning at the end of the current scan so that an image can be saved. Clicking again before the end of the frame scan stops scanning immediately. To unpause scanning, click the Pause button again (see Chapter 4 for details).

FILTERING FUNCTIONS

The ascending 6 bricks (frames) button denotes improving an image with a successive **Average** of 2 or more frames. This process continues until stopped by a change of scanning condition or by freezing the result.

The stairway 6 bricks (frames) button shows an increasing number of frames that **Integrate** to an end value. This process will continue until the predefined number of frames is reached, and then stops and pauses automatically. During and after image accumulation, you cannot change the focus or perform other image-influencing actions. The number of frames can be selected as a preset in the toolbar drop-down list box associated with the Integrate function.

SAVING / OPENING SINGLE IMAGES (STILLS)



After Snapshot or any activity that pauses the full scan frame, the following saving functions in the **File menu** could be chosen:

- **Save**
  can be clicked on to store the image to the predetermined location.
- **Save As...**
  opens a dialogue for saving images (this provides an opportunity to change the file name, its label or location, and the possibility to save Databar and overlyed graphics), STG, EPM files etc. This function is also available for the Snapshot and Photo functions under the **Preferences… / Scanning** tab Archive Option.

TABLE 5-13 IMAGE CAPTURING PROCEDURE

Step	Action
1.	Select the area of interest and set: - the **Magnification** - the **Scan condition** - the **Pixel** resolution that are required in the captured image.
2.	Make the best image using any suitable method you are familiar with.
3.	Use the **Snapshot / Photo (F2) / Pause (F6)** function. The scan makes one screen / quad pass (or several passes when the number of integrated frames is larger) and pauses.
4.	The image can now be saved by **Save (Ctrl + S) / Save As..** function in the **File** menu.
5.	The scan can be released by clicking on the **Pause (F6)** button on the toolbar.

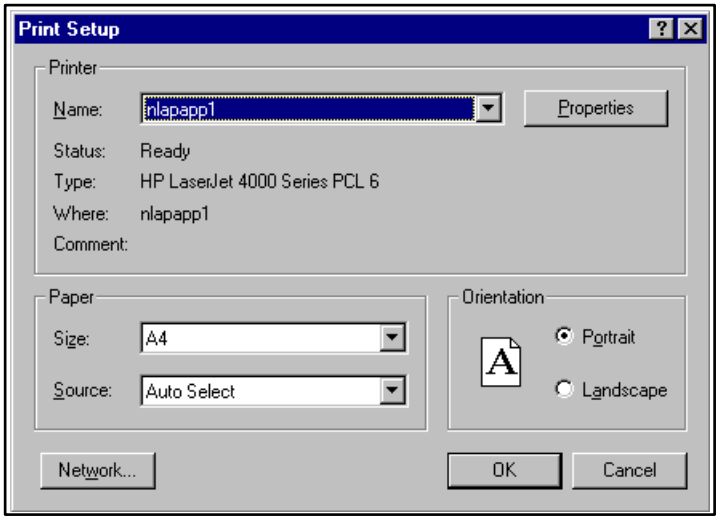
Open...

Opening a single image file to restore to a quad or the full screen can be achieved by clicking on **Open** in the **File menu**. The dialogue displays, by default, the position to open files associated to the imaging function i.e. the image file location used by Snapshot and Photo.

IMAGE PRINTING (CTRL + P)

Clicking on **Print...** opens the printer setup dialogue so that the choice of printer and settings can be established to print an image or any other printable product from the microscope. Pressing **OK** in the printer setup dialogue will activate the printer to print the job.

FIGURE 5-15 PRINTER SETUP DIALOGUE



The **Print...** word in the menu will only be highlighted when the active quad is **Paused**.

TABLE 5-14 IMAGE PRINTING PROCEDURE

Step	Action
1.	Select a **Quad**. Optimize the image conditions in that quad.
2.	**Photo** the image or open an existing image from memory into the quad.
3.	Click on **Print...** (**Ctrl + P**) in the **File** menu, a print dialog appears.
4.	Complete the print setup and click on **OK**.
5.	The image set in the selected quad now goes to the printer.

Note:
Only printers on the Quanta Support Network are available. It is not possible to print to the network printers from the microscope controller as it is not on the LAN directly.

Some printers may not work with high resolution images because they do not have sufficient memory.

Saving Multiple Images (Recording a Movie)

The movie **Record** button can be used to save an AVI file or a group of TIFF files during active scanning of Electron or Ion Beam.

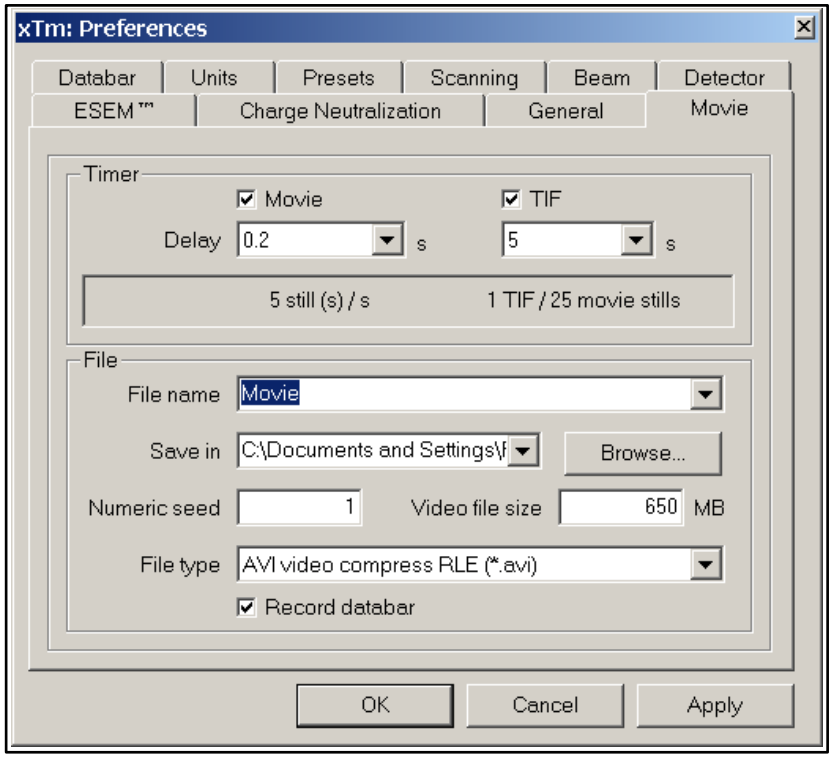
This feature provides the making of digital video files (AVI) for dynamic experiments performed with the Quanta 3D microscope. Up to 4 imaging quads can be recorded simultaneously with synchronized start. It is possible to switch between quad and full screen while the video is recording. The movie has the following embedded features:

- Resolution at 512 x 422 or 1024 x 884
- Databar image optionally included in the video
- Average or Integration changeable during recording
- Scan speed changeable during recording
- Reduced area pauses all quads for focus or C&B change
- Time remaining indicator
- Single frame TIF images recordable during video sequence
- File format compressed AVI (*.avi)
- Start, Stop and Pause onscreen indicators
- Preferences set-up dialogue

MOVIE TAB PREFERENCES DIALOGUE

The **Preferences** dialogue (**Ctrl + O**) can be found at the end of some of the menus. The **Movie** tab provides two modules one to choose set-up conditions for timing (labelled **Timer)**, and the other to set-up save conditions for the resultant movie (labelled **File)**.

FIGURE 5-16 MOVIE PREFERENCES

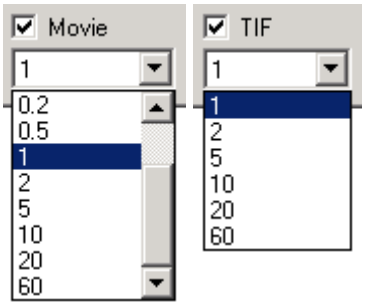


Timer module

The parameters in this section can be changed when the digital video is inactive, but are disabled during recording.

The digital video is timed asynchronously with the scanning. The recording is controlled by two timers:

1. **AVI (Digital Video) timer:**
   after AVI delay time, the acquisition buffer of each unpaused quad is stored as a new frame in the video stream. The frame optionally includes an image of the databar and a time stamp. This produces an AVI that shows the scan progressing.
2. **TIF timer**:
   after TIF delay time the system waits until the running scan in unpaused quads is finished and saves a complete image in TIF format including the databar data if chosen. The first image is saved immediately when its scanning is completed. TIF files are better to save in many cases as they can be built into a faster AVI and the databar display can be customized when building an AVI file.



Movie / TIF Check box

These check boxes determine whether the AVI movie and/or TIF files should be stored. The dropdown combo box lists the choice of delay times – periods between the two following frames / pictures in seconds. Click on a delay time value and it will be highlighted below the check box.

It is advisible to use either AVI or TIF, but not both, to produce video that is not jerky. If both AVI and TIF are recorded, the AVI may be jerky due to delays when writing TIF files to a disk. TIF delay must always be longer than or equal to the Movie delay.

If the delay time is shorter than what the system can achieve for the current setting, the recording runs as fast as possible.

At all times one of these checkboxes remains checked. If the TIF checkbox is unchecked the delay box for TIF is disabled. Similarly, if the AVI checkbox is unchecked the delay box for Movie is disabled.

Information field

This read only-area is found below the AVI and TIF combo boxes and contains additional information for the user about the number of stills (frames) per time unit (seconds, minutes) for AVI and also for TIF, if checked.

File module

All parameters in this section are only valid for the next video recording.

Digital video can be stored in *.avi files from any quad. The video name contains: generic filename, quad name and a numeric seed.

For example: ***myvideo (Quad1) 001. avi***
The filename and the numeric seed are set by the user in the movie setup. The numeric seed is automatically incremented, after the recording has stopped.

When TIF is selected, the name of the TIF files contains: generic filename, quad name, numeric seed and number of the image in the series.

For example: ***myvideo (Quad2) 003 - 00123.tif***
The series number always has 5 digits filled by zeros on the left; the first TIF file has number 00001.

File name

Enter a generic file name valid for the next video recording. A suitable file name must be entered here, if this field is not filled the Movie dialogue can not be closed.

Note:
Do not use punctuation, dashes or non alpha-numeric characters, otherwise the movie maker will not be able to build an AVI.

Save in

Enter a suitable path to the directory. If this field is not filled the Movie dialogue can not be closed. If the path is long and cannot be read in the field space the tool tip can be used to give full information.

Note:
Movie files should always be stored on the support PC to avoid filling the microscope controller hard drive.

Numeric Seed

Enter any number 1 to 999 which is converted to the three digit form with zeros on the left, if necessary.

Video file size

This value specifies the maximum size of an AVI video file in MB. Enter a size value lower than 2000 MB. After reaching this size, the video is saved and a new recording is started. If this field is not filled the Movie dialogue can not be closed. A dialogue warning appears if the hard drive lacks sufficient free space.

File type

This is a list box with types of supported digital movie formats. Normally, compressed formats are used.

Record databar

This checkbox allows the databar to be included in the video when checked. The databar in the video is updated every second.

MOVIE PROCEDURE

Start, Pause and Stop

The **red dot** is the start command button that starts the recording of three videos, one for each of the three image quads at the same moment. The Optical Image Quad cannot be recorded.

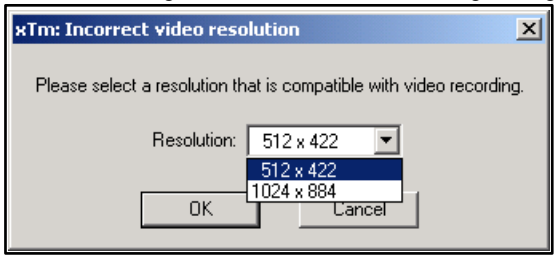
If a quad is paused when starting the video, only the first image with a time stamp is stored. When the quad is paused during the video recording, the storing of the video frames is interrupted but the video streams keep synchronization for the next unpausing. After reaching the maximum file size, the video is paused, saved, and a new video is started with the same name and incremented numeric seed.

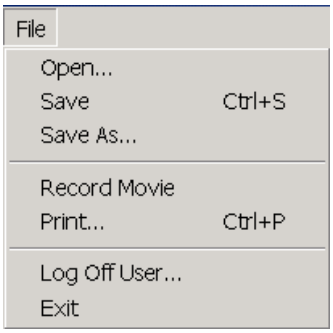
When the red dot representing ‘Start’ is pressed, it turns to a **red square**, representing ‘Stop’. Pressing the red square then stops the recording of the video of all quads and closes the files.

Recording a Movie

The following procedure describes how to setup and record a movie.

TABLE 5-15 SET-UP AND RECORDING A MOVIE

Step	Action
1.	Select **Preferences** at the base of the **Scan** menu. Click on the **Movie** tab. In the **Timer** section check the Movie check box (AVI or TIF, not both) and select from the **Delay** time combo box the desired time. Select the **TIF** function by checking the TIF check box if required and select from the TIF combo box the desired time.
2.	In the **File** section fill in the **File name** and give the '**Save in**' directory path. Fill in the **Numeric seed** value and the **Video file size**. Select the **File type** and choose whether to record the databar with the **Record databar** check box. Choose **Apply** to change temporarily to the new values or **OK** for permanent application of the values entered or **Cancel** to return to the original values at opening of Preferences.
3.	Pause those Quads which you don´t want to be active during recording.
4.	Set up the imaging in the live quad and press the **red dot** on the button bar or **Record Movie** in the **File** menu. The first frame of all quads is recorded with a time stamp. Next the recording starts and the duration is dependant on the set-up in the Preferences. When the video is started and the scan resolution is higher than 1024 the following dialogue appears: 
5.	Choose either of the resolution values and click on OK. The Movie starts to record at the selected resolution.
6.	The Movie will stop when the **red square** button is pressed on the button bar. The stop command stops recording of the video in all active quads and closes the files.



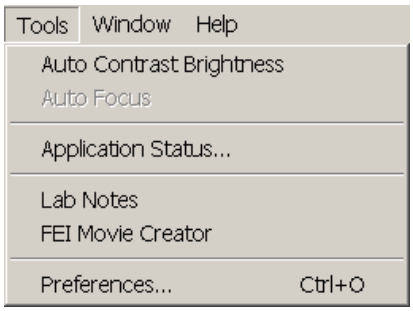
Quad Indicators

A red dot indicates that recording is active in this quad. It is displayed in the top right hand corner below the timer display.

A red dot with the Pause symbol indicates that the record is running but the data from this quad is not stored. It is displayed in the top right-hand corner below the timer display.

An estimation of the time remaining until the end of the video is displayed in the upper right corner. The time is displayed in the format hh:mm:ss. The time is calculated from the average disk space consumption and the free space on the disk.

FEI MOVIE CREATOR



This is a separate program that creates a movie from a sequence of TIF images. Click on the item **FEI Movie Creator** in the **Tools** menu to activate the tabbed dialogues.

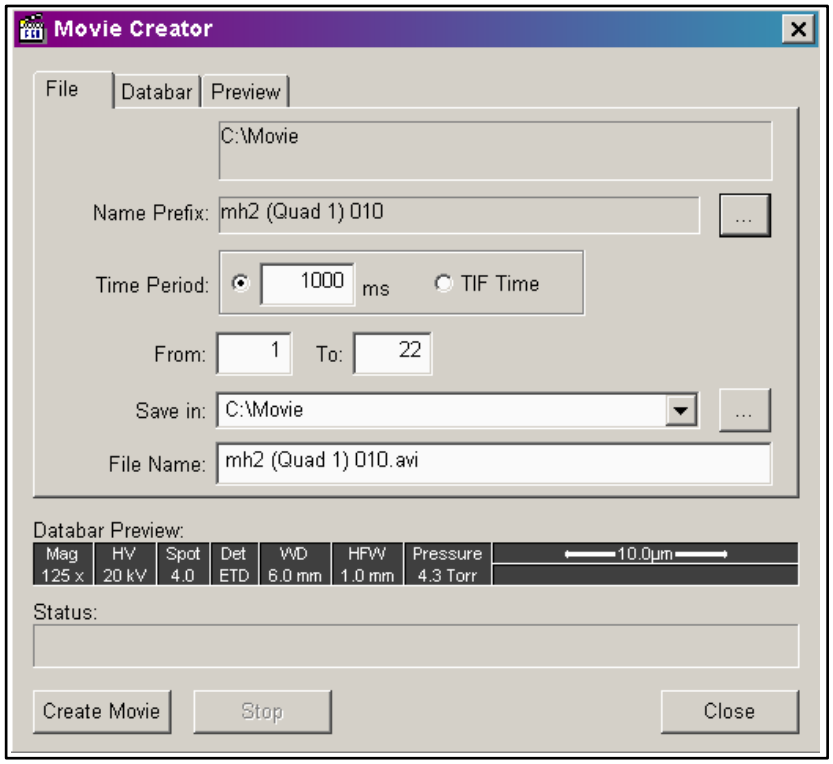
The following items are common for all tabs:

- **Databar Preview**
  displays the databar created in the Databar tab dialogue.
- **Status**
  displays the progress of movie creation process.
- **Create Movie** button
  opens the File tab dialogue and starts the movie creation process from the TIF files to a single AVI file.
- **Stop** button
  stops the creation process.
- **Close** button
  closes the **FEI Movie Creator** program.

File Tab

The File tab contains the set-up features for creating a movie from a captured sequence of TIF images made while using the Movie feature. It requires a valid file name to read the TIF files. If the TIF file names created automatically contain non-alphanumeric characters in the File Name box, this utility may not be able to compile the AVI.

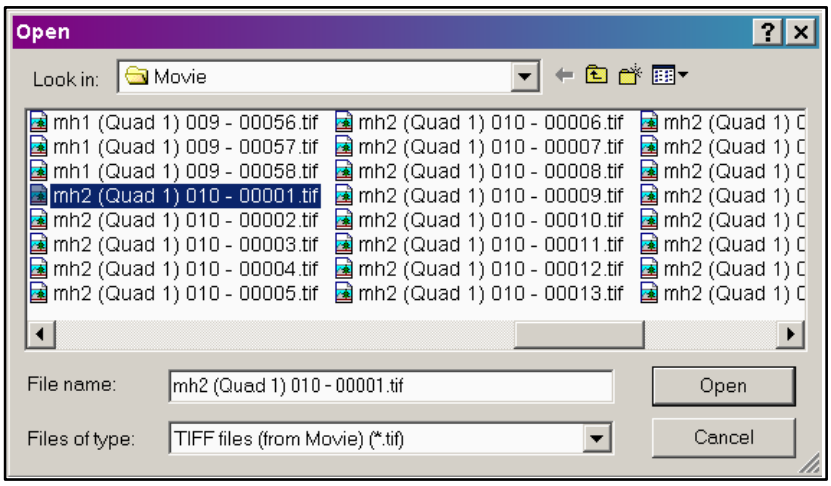
FIGURE 5-17 FEI MOVIE CREATOR 2 TAB: FILE



Name Prefix

Enter here the prefix label for the sequence of TIF images. Click on the dotted button to the right of the dialogue box to browse directories and files for the TIF sequence prefix. It does not matter which frame in a sequence is chosen.

FIGURE 5-18 BROWSE DIALOGUE


Open
Look in:
Movie
mh1 (Quad 1) 009 - 00056.tif
mh1 (Quad 1) 009 - 00057.tif
mh1 (Quad 1) 009 - 00058.tif
mh2 (Quad 1) 010 - 00001.tif
mh2 (Quad 1) 010 - 00002.tif
mh2 (Quad 1) 010 - 00003.tif
mh2 (Quad 1) 010 - 00004.tif
mh2 (Quad 1) 010 - 00005.tif
mh2 (Quad 1) 010 - 00006.tif
mh2 (Quad 1) 010 - 00007.tif
mh2 (Quad 1) 010 - 00008.tif
mh2 (Quad 1) 010 - 00009.tif
mh2 (Quad 1) 010 - 00010.tif
mh2 (Quad 1) 010 - 00011.tif
mh2 (Quad 1) 010 - 00012.tif
mh2 (Quad 1) 010 - 00013.tif
File name:
mh2 (Quad 1) 010 - 00001.tif
Open
Files of type:
TIFF files (from Movie) (*.tif)
Cancel

Time Period

Either select a custom time for the playback of the movie by clicking on the millisecond radio button, or on the TIF time radio button to select real time (acquisition = playback). To find the best custom timing one may need to create the movie a few times. 200 ms is good for most movies to speed up the action.

From (Frame numbering)

Enter the numbers of the starting frame and the ending frame. These will represent the sequence beginning to end. This will be autofilled with the beginning and ending frames available.

Save in (Path)

Enter the path where the AVI file should be saved. Click on the dotted button to the right of the dialogue box to browse the directories for the path needed on the support PC.

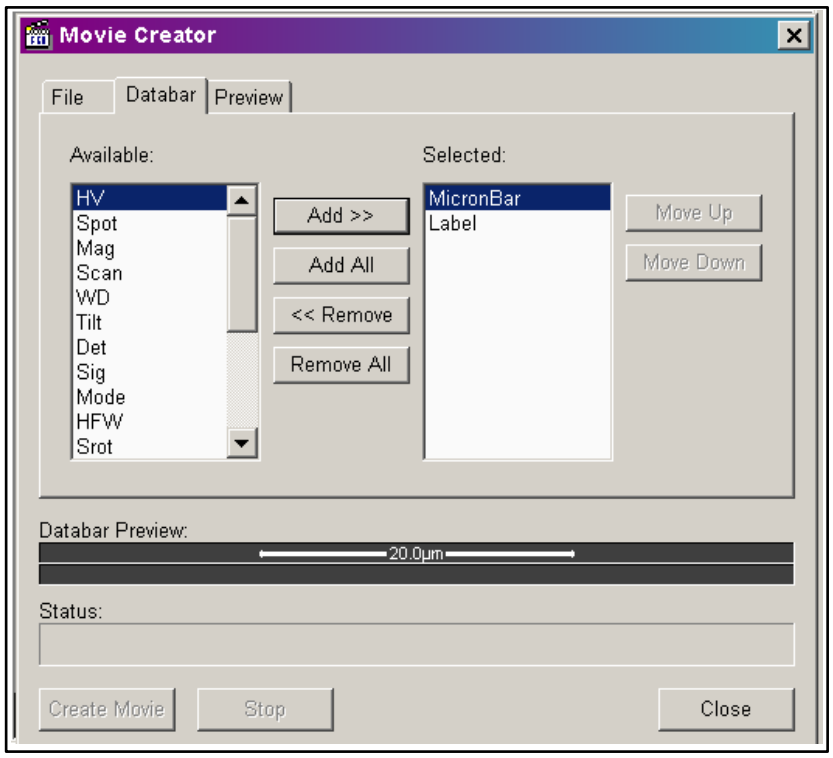
File Name

Enter the file name for the AVI file to be saved. If this is not filled in, the default prefix (first image) will be used, and the edit box will be filled automatically.

Databar Tab

The **DataBar** Tab contains two lists, one labelled **Available** and the other **Selected**. Items in the Available list can be added individually or as a whole to the Selected list. The Selected list, when completed, contains all items that will be displayed in the DataBar at the base of the movie display. The order of the items in the Selected list can be arranged according to priority or preference. This will in turn change the order of the displayed items in the DataBar. Items can be removed from the Selected list singularly or as a whole back to the Available list. This facility does not affect the quad and full screen databar and is only dedicated to the **FEI Movie Creator 2**.

FIGURE 5-19 FEI MOVIE CREATOR 2 TAB: DATABAR



Available / Selected

Available list for all the items that can be entered in the databar and Selected list for all items that will be present in the databar.

Add / Add All

Adds one / all item(s) from the Available list to the Selected list.

Note:
Since there is a finite amount of databar space, any items that exceed the allowable space will be cut off.

Remove / Remove All

Removes one / all item(s) from the Selected list to the Available list.

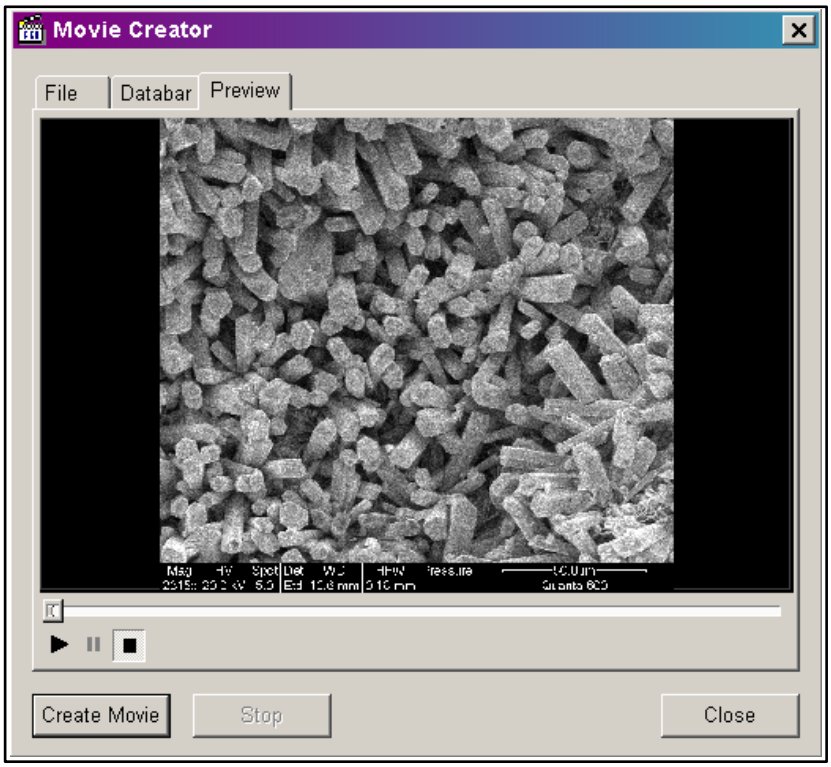
Move Up / Move Down

Move an item up / to the left or down / to the right in the Selected list / in the actual databar display.

Preview (tab)

Once the movie is created, opening the Preview tab will automatically display the first image of the movie sequence. Clicking on the Play button causes the movie to play and the progress indicator below the movie will move from left to right at a speed depending on the play timing of the movie.

FIGURE 5-20 FEI MOVIE CREATOR 2 TAB: PREVIEW



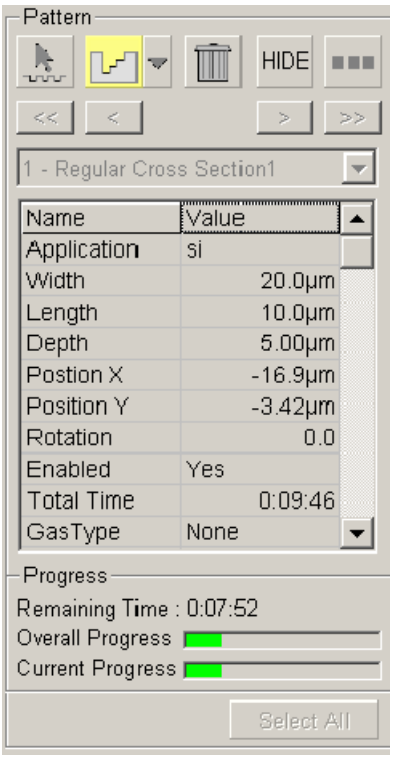
Start / Pause / Stop buttons

Click on these buttons to Start, Pause or Stop the movie. By holding the adjuster one can run forward or backward through the movie.

PLAYING A MOVIE

The AVI file movie can be played in Windows Media Player, installed on the support PC, or exported to another Windows PC with more advanced movie editing programs. Programs used to play the movie need to recognise the *.avi file type.

Patterning



Patterning is the process of milling, depositing, or etching a pattern into the sample surface with the beam. During patterning, the selected beam unblanks automatically and uses digital beam placement to vector scan over a pattern. While patterning can be done with either beam, the electron beam is generally used for imaging and sometimes for deposition with patterns.

The Ion beam is used to cut cross sections and tracks, drill vias, and deposit new material. In general, patterns need to be cut as quickly as possible, while maintaining sufficient edge resolution and preventing potentially damaging charge buildup.

During deposition, the beam is unblanked and a Gas Injection Valve is opened to begin deposition.

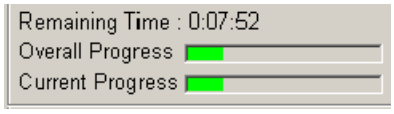
Multiple Gas Injection Systems (GIS) may be installed on your system. You select between milling, Pt deposition, Enhanced Etch, etc., by selecting a material file for a given pattern in Patterning property editor. You must define a pattern before a material file can be selected. A given material file will automatically select the appropriate GIS check box, calculate the proper dose, and set the dwell and overlap appropriate to the beam chemistry.

Before the patterning with the GIS starts the GIS needle must be inserted manually and the gas reservoir heated. The opening / closing of GIS valves is done automatically during patterning.

The GIS check boxes can be selected manually, but note that overlap and dwell should be set carefully with particular gasses in mind to avoid disappointing results.

Serial milling or deposition will always begin with the first pattern defined in the current image window and continue through patterns 2, 3, etc.

You can select a pattern with the arrow tool, change the appropriate GIS valve status from closed to open, and thereby change the pattern from one to be milled to one to be deposited. In Serial mode, a series of patterns could even be a combination of some to be milled and some to be deposited, but in general this is not recommended.



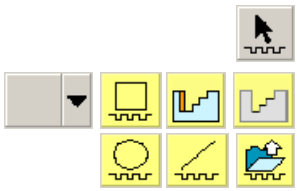
The **Progress** module displays the remaining pattern time in a progress window.

MAGNIFICATION AND PATTERNS

If the magnification is too high, milling certain patterns can use too much memory. If it is too low, the pattern corners become round and the edges become jagged. A good rule of thumb is to pick a magnification where your pattern fills 35-50% of the screen.

PATTERNING TOOLS

At the top of the Patterning Page is a selection of tools (icons) for creating, moving, sizing and deleting patterns:

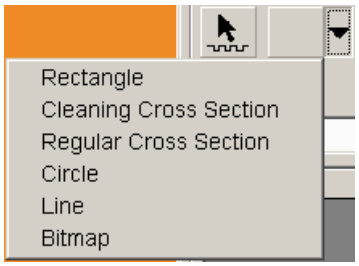


- **Pattern Control Cursor:** yellow backround when active, grey when inactive
- **Pattern selector:** Clicking the arrow activates the dropdown list. When a selection is made the blank area displays an appropriate Icon: **Rectangle / Cleaning Cross Section / Regular Cross Section / Circle / Line / Bitmap (import)**
- **Trash Can (Delete):** Clicking displays a black staggered line surrounding the icon and deletes the present selected pattern.
- **Hide:** Clicking displays a black staggered line surrounding the icon and hides the currently selected pattern.
- **Patterning sequence:** Clicking displays a black staggered line surrounding the icon.

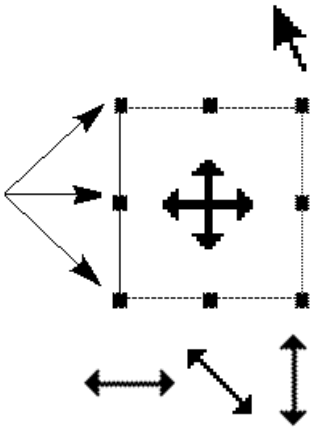
  Serial Patterning: All patterns defined on the screen are milled *consecutively*; milling is completed on one pattern before moving to the next. Serial patterning is always used with cleaning cross sections.

  Parallel Patterning: All patterns defined on the screen are milled *concurrently*. For example, if three lines are defined as milling patterns, one pass of the beam will be made on one, then the next, the third, back to the first, and so on until all three lines are milled to the depth selected for the first line.
  With parallel patterning, the mill time is recalculated to include all the patterns that are displayed in the image window. Parallel patterning is typically used for regular cross section milling and to avoid redeposition of material on adjacent areas. Onscreen information is updated as the milling progresses.

PATTERN AREA CREATING



Select one of the patterns from the **Patterning** page with the pattern selector cursor. Once selected, the cursor is ready to draw a pattern onscreen. This is only possible in the quad or the single screen, whichever is active. Draw a suitable pattern size with the draw cursor. Use the pattern control cursor to resize and move the pattern by dragging it with the mouse.



PATTERN AREA EDITING

Once a pattern has been drawn, it can be modified.

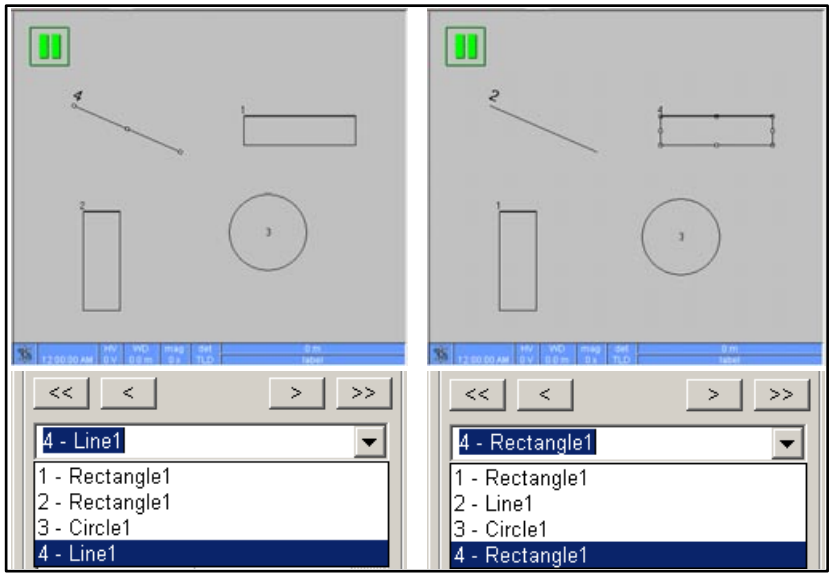
- **Focus On Pattern** is denoted by the addition of resizing handles to the pattern outline (use Pattern control cursor).
- **Moving Pattern:** Place the cursor inside the boundary of the pattern and hold the left mouse button while dragging it (use move cursor).
- **Resizing Patterns:** Hold the left mouse button and drag the resizing handle until the desired size is reached (use horizontal, vertical or diagonal resizing cursor). This can also be achieved by entering values in the Property list.

Select the Pattern control cursor button after defining a pattern to exit pattern editing mode.

MILLING ORDER OF PATTERNS

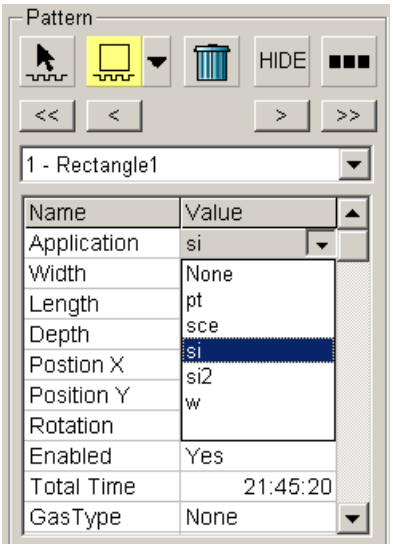
Patterns are normally milled in the order they are created on the screen. The order can be changed by focusing on the pattern you wish to change to a particular position in the order and click on the single arrow in either direction to come to the order number required. To place a pattern at number one position click on the left double arrow while focus is on the pattern. This will bring it to number one position. For the last position click on the right double arrow in the same manner and the pattern will be made the last in order. The remaining patterns mill in the order in which they were created. You can also reorder the entire set by clicking on the patterns in the order you want them to mill.

FIGURE 5-21 REORDERING PATTERNS



Numbers are displayed close to the pattern (in front of its name) to indicate the current order.

THE PATTERNING PROPERTY EDITOR

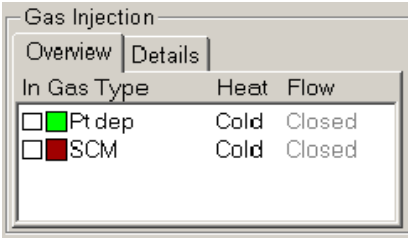


allows changing the properties of the selected shape or shapes. It displays the properties in a fixed sequence, such that the most often needed properties are at the top.

- **Application**: Clicking on the value slot next to the application produces a dropdown arrow. Click on the arrow and a list of applications will be displayed. Click on the one required and it resides in the Value slot. This sets the subsequent properties. There are pre-defined (non-editable) and user-defined (saved) applications.
  Some of these Application files use GISes. This is now the active application file for the GIS. The appropriate application file should be used with the gas type it was written for.
- **Width / Length / Depth**: dimensions of the pattern when finished.
- **Position X / Y** of the pattern relative to the origin (the quad center).
- **Rotation** of the patterns. The positive direction is counter-clockwise, default value is 0°.
- **Enabled**: If a shape is disabled then it is not included in patterning.
- **Total Time**: Time required to pattern this shape.
- **Gas Type**: The gas that must be used to pattern this shape (or None if no gas is to be used). Note that this determines the colour of the pattern on the screen.
- **Beam**: The beam current and beam diameter updates to the new beam.
- **(total volume) Sputter Rate (RV-total)**: The speed at which material is removed or deposited.
- **Dwell Time (tdwell)**: The time the beam spends on a single pixel per pass. Changing this influences the Total Depth and Total time, assuming a constant Number of passes.
- **Volume per dose (Vd)**: The volume of material that is removed per Coulomb.
- **Saturation sputter rate (RL-sat)**: The maximum linear sputter rate for a given gas. For Gas=None this is 0.
- **Saturation current density (Jsat)**: The current at which 63% of the saturation sputter rate is reached.
- **Maximum dose per area (Dpa-max)**: Describes the adsorbed gas layer, allowing a certain dose to be deposited at a higher rate than the saturation current density, allowing a temporary higher rate.
- **Refresh Time**: The minimum loop time that must at least elapse before the next pass, so that the adsorbed gas can be refreshed.
- **Loop Time**: The time between the start of one pass and the next (read only).
- **Shape Area**: The surface area of the pattern. Note that the area is not simply the bounding rectangle, for example a Grouped shape may have a much smaller Area (the sum of the Area's of the grouped shapes) than its bounding rectangle.
- **Number of Passes**: That the beam makes over the pattern. Changing this will change the Depth.
- **Defocus (WD)**: of the beam (WD change).
- **Blur (dblur)**: Like Defocus, but specifying the (additional) diameter of the blurred spot.
- **Interaction diameter (dinteraction)**: for an infinitely small beam.
- **Total Diameter (dtotal)**: The combination of the beam diameter and interaction diameter (read-only).
- **Total Beam Time**: the total time that the beam is unblanked for this shape.

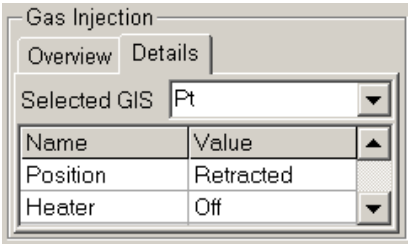
THE GAS INJECTION MODULES (GIS)

provides the capability to select the type of gas deposition or etch material.



Overview Tab

- **In** check box: In (checked) / Out (Unchecked)
- **Gas Type** check box: the gas assignment to the port (the pattern has the colour of the gas used)
- **Heat** status: Cold / Hot
- **Flow** status: Closed / Open



Details Tab

displays the characteristics of the active Gas Injector. The characteristics can be changed by entering the details to configure the injector.

Selected GIS

In Patterning editor an application file which uses some of the installed GISes may be choosen for a given pattern.

CHOOSING A GAS TYPE

Gas types are used to deposit on or etch away surface material. A gas type will be allocated to each Gas Injector, and up to 3 gas injectors can be mounted on the system in total. If an OmniProbe is mounted then up to 2 GIS's can be mounted.

The Gas Type files are found in the PROPERTIES list under GAS TYPE on the **Pattern** page. Clicking on the right of the entry will promote a dropdown arrow. Click on the arrow and a list of allocated gas types for the GIS system will be displayed up to the number of GIS's installed. Click on the one required and it will reside in the GAS TYPE slot in the PROPERTIES list. This has now allocated the GIS to be used with its gas type.

Choosing an application file in patterning property list automatically sets the appropriate gas type.

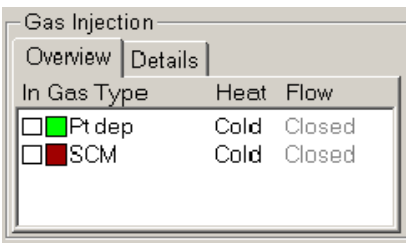
When choosing from the list on the **GIS** module only the GIS gas type chosen in the Pattern PROPERTY EDITOR is ready for active use.

SETTING UP THE GIS

The GIS to be used should be setup before patterning is started. It must be held heated and inserted but not open until it is necessary to use.

When not in use the GIS should be closed, cold and retracted. Leaving it closed, heated but retracted is also an option if it is to be used over several patterns so that reheating is not necessary.

TABLE 5-16 SETTING UP THE GIS



Step	Action
1.	Open the **Overview** tab in the **Gas Injector** module: Double click on the word **Cold** below the column heat for the GIS you need to use or by clicking the right mouse button over the GIS module will open a dialog list where the word **Heater** is highlighted. Click on heater.
2.	The word COLD is replaced by a progress bar, which in turn is replaced by the word WARM when the GIS is fully heated.

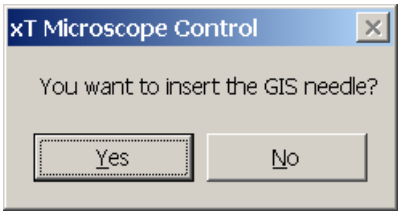


TABLE 5-16 SETTING UP THE GIS

Step	Action
3.	Tick the IN box at the start of the GIS chosen. A dialog appears asking for confirmation of insertion of the GIS. Confirm the insertion if you know there is nothing obstructing its travel.
4.	Double click on the word CLOSED below the column FLOW for the GIS you need to use. The GIS will open. Clicking the right mouse button over the GIS module will open a dialog list where the word FLOW is highlighted. Click on FLOW and the GIS will open. If application file in patterning property list is choosen, the opening / closing of GIS valves is done automatically.
5.	The GIS is now in operation and is either depositing or etching depending on the GAS TYPE chosen from the Pattern PROPERTY EDITOR.

SETTING UP THE EPM

To set up the EPM for monitoring use before patterning use the following procedure.

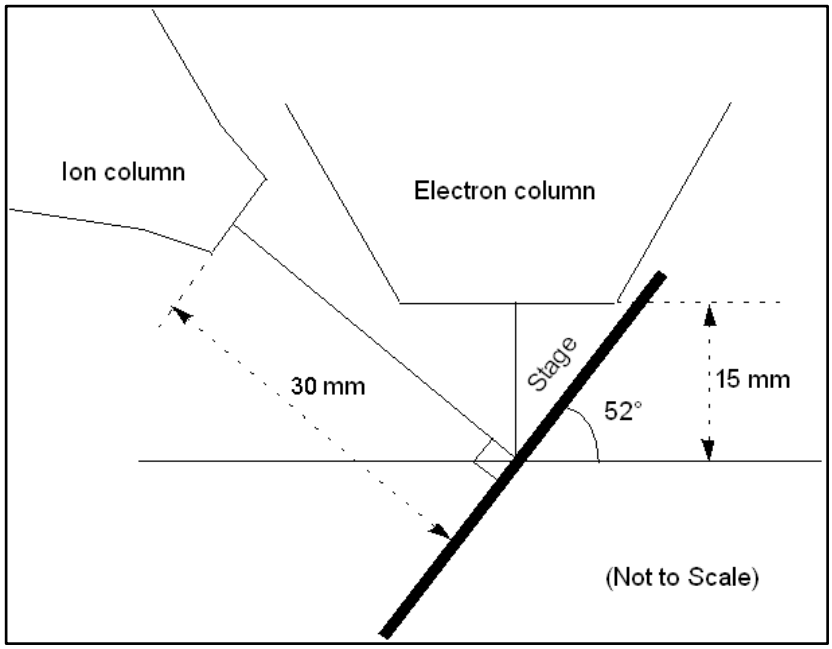
TABLE 5-17 SETTING UP THE EPM

Step	Action
1.	Select the ACTIVE LIVE# option from the dropdown list in the **Options** tab.
2.	Select the required conditions in the property editor in the **Options** tab, such as LINE TYPE and LINE COLOR.
3.	Open the **Scaling** tab and select either TIME or DEPTH, from the X UNITS dropdown list, as the progress criteria : **Auto-zoom** scales the entire progress to the viewing window. **Fixed-zoom** can be setup by entering threshold max / min values for time (seconds) in the x axis, and max/min values for current (nA) in the y axis. **Auto-pan** will keep the present milling position progressing in the viewing window while the past progress moves off screen.
4.	Select the **Graph** tab to view the progress.
5.	Click on the **EPM** button in the toolbar. The EPM will continue with a baseline in the **Graph** display until patterning has started.
6.	Start patterning.

BEAM COINCIDENCE

The Electron and Ion columns are mounted as illustrated in the following figure, which shows the stage tilted to 52°. Coincidence of the beams occur at the eucentric tilt axis.

FIGURE 5-22 BEAM COINCIDENCE



Correcting Beam coincidence

1. Set the eucentric height position (see Chapter 7).
2. Select E-beam in first quad and I-beam in second quad.
3. Focus the same obvious feature on the sample with both beams.
4. Use the I-beam shift control to correct any offset in the coincidence of the two visualized features. The accuracy should be within 5 µm.

Test Pattern

A test pattern can be made with a simple pattern using the Ion beam and after observing it with the Electron beam to see that it has correct coincidence of beams.

Milling Procedure

Bring sample to the eucentric position and make 52° tilt. Now you can start to mill a pattern on the sample material. The procedure is as follows.

TABLE 5-18 MILLING A PATTERN

Step	Action
1.	Select a pattern from the PATTERN SELECTOR on the **Patterning** Page, and draw a pattern in the active Quad.
2.	Select a beam for patterning from the toolbar.
3.	Enter a value in µms as the DEPTH in the PROPERTY EDITOR.
4.	Select the milling aperture.
5.	Focus and stigmate the beam on the area adjacent to the pattern. Save position where you want to mill so that you can easily return there after you have optimised the image.
6.	If necessary, use the MUI SHIFT X and Y knobsor resize the pattern to correct positioning.
7.	Snapshot a single frame to confirm the pattern position.
8.	Switch on the EPM.
9.	Click **Start patterning** on the Patterning menu or click on the Start patterning button on the toolbar to begin milling.

If at any time during milling or deposition you wish to stop in progress, click on the **Pause Patterning** icon on the toolbar. When you pause and restart patterning, the software continues the patterning process where it left off.

If patterning is stoped and / or restarted after patterns are modified, added, or deleted, patterning starts from the first pattern and all patterning completed clocks are reset to zero.

FINE TUNING PATTERNS

Use the MUI SHIFT X and Y knobs to fine-tune the image. Beam shifts are used in many applications, such as fine milling of cross sections to give a clean, vertical face to the section. Use Shift also to adjust for drift or charge effects. Grab-a-frame to monitor the change in mill position or carefully observe it from the live real-time monitor image.

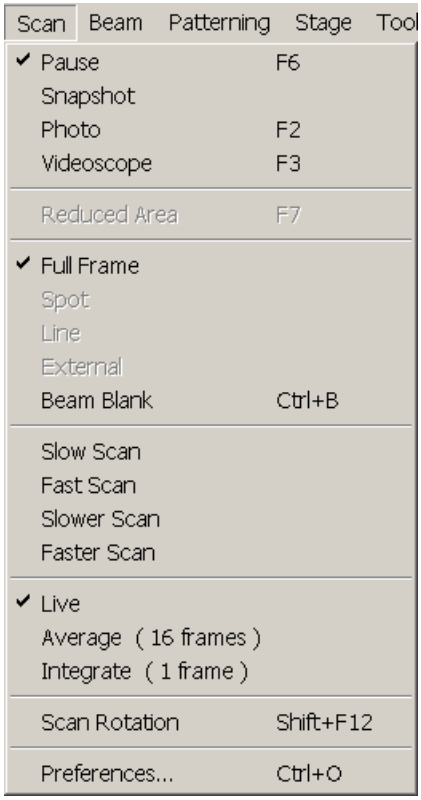
SUGGESTED BEAM CURRENT/MILLING TIMES

The appropriate beam current value depends on the sample to be milled and your experience with the sample material. Lower beam currents are less destructive but take longer to mill. The following are guidelines only. Specific parameters depend on your sample material and objectives.

TABLE 5-19 BEAM CURRENTS/MILLING TIMES BY APPLICATION

Milling Application	Suggested Beam Current/Milling Time
Typical cross sections (< 20 µm wide)	Try for a total time of 5-15 minutes, using 2-5 nA of current. Larger currents cause more damage around the recess and less vertical walls.
Large cross sections (very wide or deep ones)	Raise milling time to 15-20 minutes or more (beware of drifts), using 5 - 20 nA current.
Cleaning cross section	Use a value no less than one quarter to one half of the main current (500, 300, 100, 50 nA).
Drilling vias or cutting tracks	A drilling time from 1-4 minutes is adequate. The main limitations of short drilling times are difficulty in doing End Point Detection and the possibility of doing charge damage.

MILLING IN SPOT MODE



Select **Spot** from the **Scan** menu to place a single spot directly in the center of the screen. The cursor becomes an open green cross in the center of the screen. If the cursor is not moved the milling process will take place in the center of the screen. Click anywhere on the image to move the green cross to another position for spot milling.

TABLE 5-20 MILLING A SPOT

Step	Action
1.	Move your feature to the center of the screen.
2.	Select SPOT from the **Scan** menu. A open green cross is displayed in the center of the screen. Move the cursor over the spot required for milling.
3.	Click on the START PATTERNING button in the toolbar.
4.	To grab a frame, click on SNAPSHOT.
5.	Click PAUSE once to resume SPOT mode scanning.
6.	To exit SPOT mode, chose FULL FRAME.

CHARGING SAMPLES

In case of charging samples Charge neutralisation utilizing electron beam must be used to preserve pattern shift during milling. Charge neutralisation is activated in the Electron Beam Current module on the Beam Control page by clicking Neutralisation button. This opens preference window on Charge Neutralisation Tab (see Setting Preferences later in this chapter). Decisive criterion for appling of HV, spotsize and defocus is that the image stops to move while imaging. Applying Charge Neutralisation changes image appearance so the C&B could be set to optimise image. Switching off Charge Neutralisation brings the C&B to original values.

CREATING CROSS SECTIONS

Cross sections are cut in a stair step fashion to allow the exposed layers to be seen with electron beam when the stage is tilted to 52°.

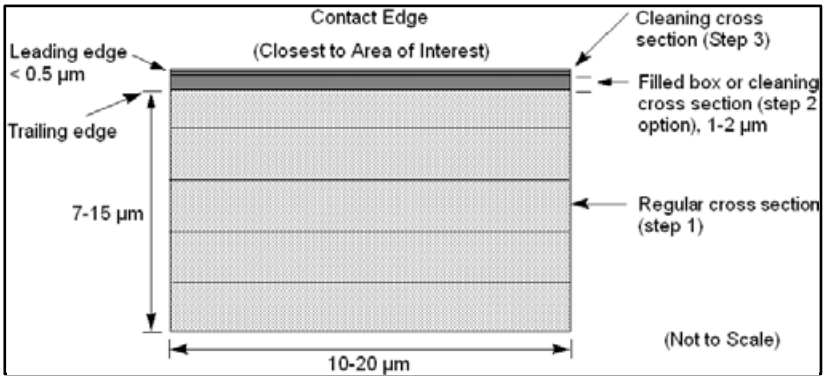
Mill a typical cross section in two or three stages.

1. The first stage is regular cross section with five superimposed box patterns sharing three common edges.
2. Optionally, use either filled box or cleaning cross section at a reduced current. (If the cross section is large, a second cleaning may be required at a lower current.)
3. Finally, use cleaning cross section.

The following figure shows the relationship of these pattern areas and their relative size.

A typical cross section is 10-20 µm wide by 7-15 µm tall with the dimensions and depth appropriate to the size of the target area of interest.

FIGURE 5-23 A TYPICAL CROSS SECTION



Use caution in positioning boxes if you are sectioning a very specific point. Use fine milling to expose the exact area of interest. For example, a 2 µm offset should be more than enough at 2 nA of current.

Calculate the outline as the height of the box relative to the depth to be milled. If you intend to view at 52° and see details 3 µm from the surface, then the original box should be at least 3 µm tall.

Making the First Cross Section

Mill a regular cross section with five superimposed box patterns sharing three common edges.

TABLE 5-21 MAKING THE FIRST CROSS SECTION

Step	Action
1.	Select a first Quad by clicking in it, and the **E-Beam** icon from the toolbar and begin scanning.
2.	Find the eucentric position.
3.	Move the stage to where you want to mill the cross section.
4.	Tilt the stage to 52°.
5.	Save this position in the LOCATION list in the STAGE module.
6.	Move the stage to a new position for optimization of the I-Beam image.
7.	Align both beams by correcting the coincidence found in the section *'Beam Coincidence'*.
8.	From the toolbar select the second quad and click **I-Beam** icon. Set the I-Beam current to 150-5000 pA, depending on the size of the cross section.
9.	Optimize the I-Beam image.
10.	Restore the stage position you stored in Step 5.
11.	Image briefly on the area to set the magnification and position.
12.	Click SNAPSHOT to grab a I-Beam frame.
13.	Open the **Patterning** page and do the following: Select REGULAR CROSS SECTION from the pattern tools menu on the **Patterning** page. Bring the cursor to the image area and draw a rectangular box about 2 µm from the area of interest.
14.	While still on the **Patterning** page. Within the property editor set the APPLICATION to '*si*' and enter the value for the DEPTH as needed. Press ENTER to update.
15.	Click SNAPSHOT to grab a I-Beam frame.
16.	Click on the START PATTERNING icon in the toolbar.
17.	Use SNAPSHOT to update your image as desired by grabbing a frame from the Ion-Beam or E-Beam. Note that grabbing multiple frames will affect the depth slightly as the total pattern time-clock continues to run while you are grabbing frames.

Making the Second Cut (Optional)

Use CLEANING CROSS SECTION from the pattern tools menu at a reduced current for this step.

TABLE 5-22 MAKING THE SECOND CUT (OPTIONAL)

Step	Action
1.	From the toolbar set the I-Beam current to approximately ¼ of the beam current used for the first cut.
2.	If you haven't already done so, align both beams with the Beam Coincidence procedure.
3.	Click SNAPSHOT to grab an I-Beam frame.
4.	Click CLEANING CROSS SECTION. Bring the cursor to the image area and draw a rectangular box. Adjust its size so that its leading face is approximately 0.2 µm from the target area and the trailing edge extends just beyond the rough cut. **Remember to fill in the depth of your cross section in the property editor on the Patterning page.**
5.	Snapshot another I-Beam frame to check alignment of the pattern to the feature.
6.	Click on the START PATTERNING icon in the toolbar.
7.	Select a new Quad by clicking in it, and the **E-Beam** icon from the toolbar and begin scanning. Click SNAPSHOT to grab a frame to view the E-Beam image.

Making the Final Cut

Use CLEANING CROSS SECTION from the pattern tools menu for this final cut.

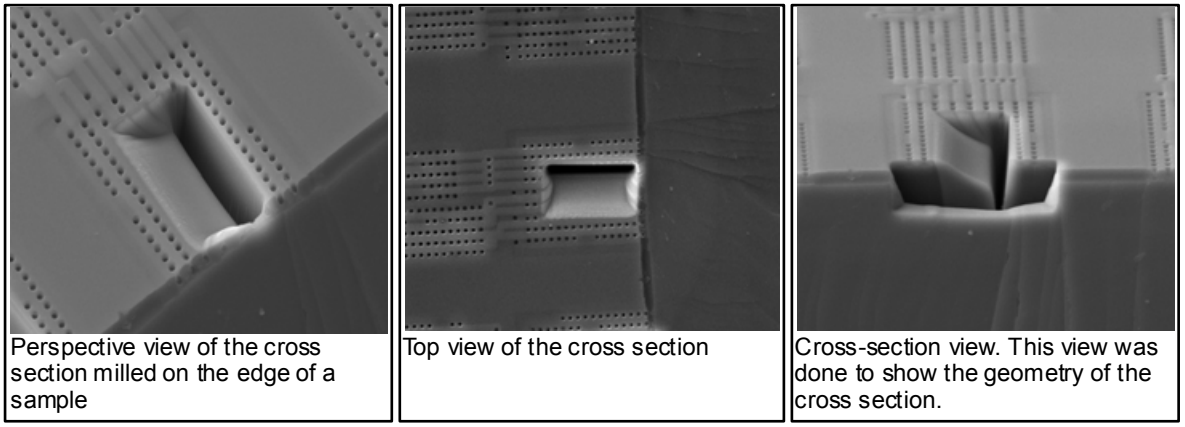
TABLE 5-23 MAKING THE FINAL CUT

Step	Action
1.	If the cut is too rough, change the Ion beam current to 100 - 1000 pA. Adjust focus as needed.
2.	In the patterning Quad click SNAPSHOT to grab a I-Beam frame.
3.	Click CLEANING CROSS SECTION. Bring the cursor to the image area and draw a rectangular box. Adjust its size so that its leading face crosses the target area and the trailing edge extends just beyond the rough cut. **Remember to fill in the depth of your cross section in the property editor on the Patterning page.**
4.	Click SNAPSHOT to grab a I-Beam frame.
5.	Click on the START PATTERNING icon in the toolbar.
6.	Select a new Quad by clicking in it, and the **E-Beam** icon from the toolbar and begin scanning. Click SNAPSHOT to grab a frame to view the E-Beam image. SSD BSE detector (if available) is suitable for this electron imaging during ion patterning.

VIEWING CROSS SECTION

After cutting the cross section, lower the ion beam current to 10 or 30 pA and tilt 52° to view the cross section with the ion beam. The following figure shows examples of some typical milling views of a cross section.

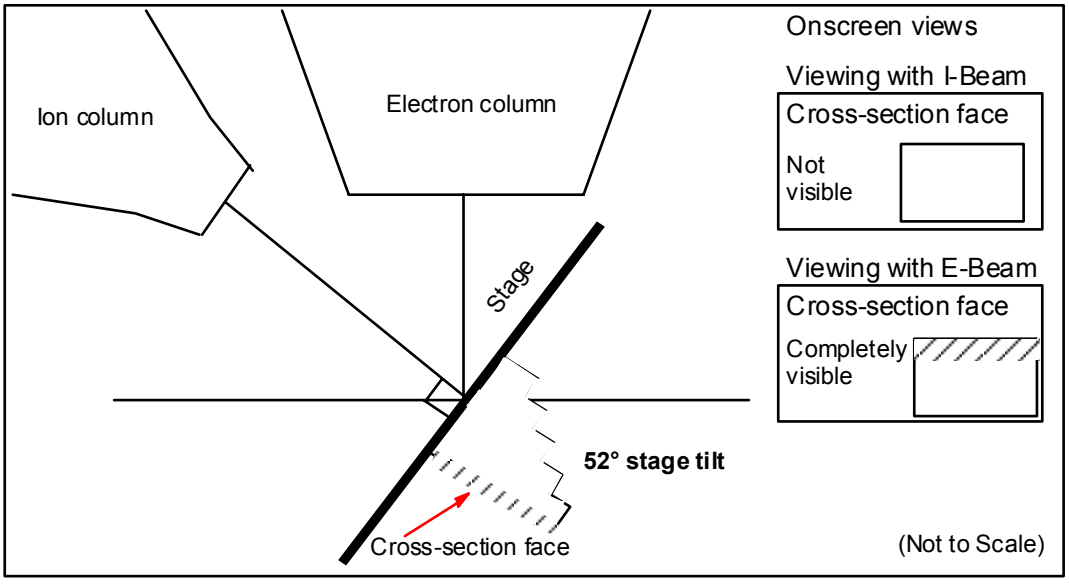
FIGURE 5-24 CROSS SECTION VIEWS



Perspective view of the cross section milled on the edge of a sample	Top view of the cross section	Cross-section view. This view was done to show the geometry of the cross section.

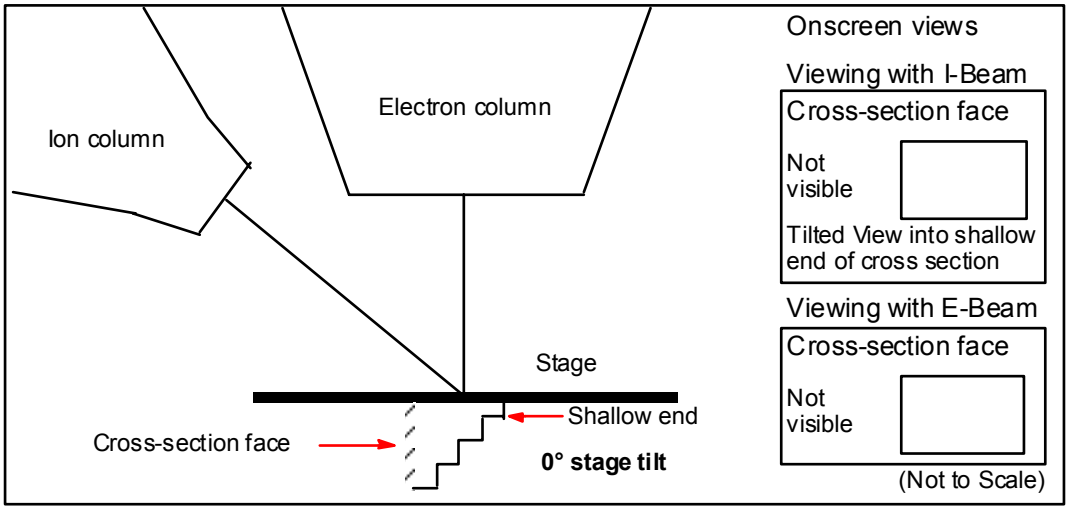
The following figure shows the relationship of the columns and stage to the face of the cross section during milling and how this is viewed onscreen, depending on whether you image with the electron or ion beam.

FIGURE 5-25 CROSS SECTION VIEWING DURING MILLING



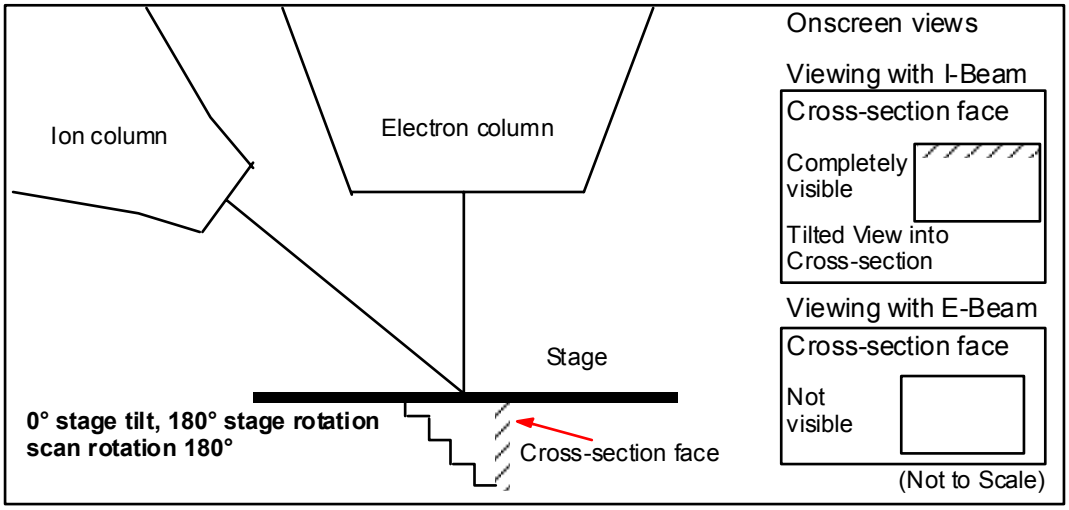
The following figure shows the onscreen view with the stage at 0° tilt, with both the electron and ion beam imaging views.

FIGURE 5-26 CROSS SECTION VIEWING AT 0°TILT

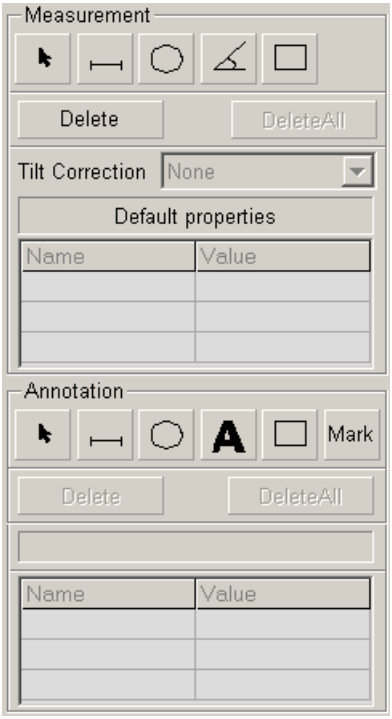


The following figure shows the onscreen views with the stage still at 0° tilt, but with both stage and ion beam scan rotation at 180°.

FIGURE 5-27 VIEWING AT 0° TILT ROTATED 180°



The Measurement and Annotation Functions



found on the **Processing** page give the user many capabilities to measure distances, angles, diameters and areas / to locate and label items that are of significant interest on the sample area.

Clicking on the appropriate symbol button at the top of either module opens a property list where items such as Color, Font, line width, measurement type and text position etc. can be defined.

The graphic chosen can then be drawn on screen with that symbol cursor. Once the graphic is drawn, the ARROW symbol button can be clicked on to change the graphic properties (size, shape etc.). If there are more graphics on screen the arrow button can also be used to focus on one in particular by clicking on the graphic when using the ARROW symbol.

TOOLS

At the top of the either module is a selection of tools - icons / buttons / propety list:

- **Arrow** icon: selecting tool
- **Line** icon: line creating tool
- **Circle** icon: circle creating tool
- **Rectangle** icon: rectangle creating tool
- **Angle** icon: angle creating tool
- **Text** icon: text creating tool
- **Mark** icon: mark creating tool
- **Delete** button: deletes only item(s) selected
- **Delete All** button: deletes all on screen items created via appropriate module
- **Properties List:** whether to gain statistical information or to change a property of a measurement or annotation you can enter the property list for the graphic or text you have selected. Some properties have a dropdown list so a choice can be made which updates on screen for the selected graphic. Numerical values can be entered in text editors with the use of text cursor in the edit area.

MEASUREMENT MODULE

Measurement can be used to gain statistical information about a milled area by overlaying the shape with a measurement graphic to outline sizes within the area. By changing the magnification these graphic elements resizes accordingly.

TABLE 5-24 USING MEASUREMENT FUNCTIONS

Step	Action
1.	Click on the **Measurement** graphic symbol suitable for the milled item you need to gain measurements from i.e. rectangle for a standard rectangular patterned milled area.
2.	Bring the cursor to the quad or screen area and draw the graphic over the milled area, to represent the milled shape. This can be done by dragging the cursor from the top left corner to the right lower corner of the shape.

TABLE 5-24 USING MEASUREMENT FUNCTIONS

Step	Action
3.	With the use of selecting tool click on the graphic to size and position it correctly over the milled area.
4.	Although there is a value already in the center or alongside the graphic, this is only one of a number of statistics available. These can be found in the **Property list** for that graphic. When there are more than one graphic the ARROW cursor can be used to gain information from each in turn.

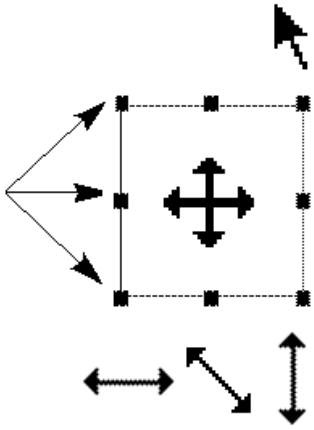
ANNOTATION MODULE

Annotations can be used to graphically label items of interest. Text can also be used to add further information about it.

TABLE 5-25 USING ANNOTATION FUNCTIONS

Step	Action
1.	Click on the **Annotation** symbol required.
2.	Bring the cursor to the quad or screen area and draw the graphic. This can be done by dragging the cursor from the top left corner to the right lower corner of the shape. If you chose the **Text** symbol then just click once where you require text and a text box opens. Type the text into the text item in the **Property** list. Click on the text with the left mouse button or press enter and the text will appear on the screen in the area of the box.
3.	With the use of selecting tool click on the graphic to size and position it correctly over the sample area.
4.	Condition in the **Property** list can be changed to effect changes onscreen for text especially but also graphics for color etc.

EDITING MEASUREMENTS / ANNOTATIONS



Once a Measurement or Annotation symbol has been drawn, it can be modified.

- **Selected graphic** is denoted by the addition of resizing handles to the graphic outline (use arrow cursor).
- **Moving graphic:** place the cursor inside the boundary of the graphic and hold the left mouse button while dragging it (use move cursor).
- **Resizing graphic:** hold the left mouse button and drag the resizing handle until the desired size is reached (use horizontal, vertical or diagonal resizing cursor). This can also be achieved by entering values in the Property list.

Select the Arrow (selecting tool) button after defining a graphic to exit graphic editing mode.

Setting Preferences...

The preferences dialogue can be activated by selecting **Preferences... (Ctrl + O)** at the end of most of of the menus.

Note:
Preferences for Electron and Ion beams have the same features. Following descriptions and figures are made only for Electron beam. Detector preferences menu handles individual choices of Detectors with direct dialog.

THE PREFERENCES TAB DIALOGUES

The background setting for day to day or individual personal operation can be made by entering or changing characteristic in any of the tabbed dialogues found in the **Preferences...**

It depends on the opened menu where Preferences... is chosen that dictates the tab opened on entry to the **Preferences dialogue**. Once the Preferences dialogue is opened any of the tabs can be chosen. Only one tab can be opened at any time.

At the bottom of any Tab there are three buttons:

- **OK** button to bring the new settings into operation
- **Cancel** button to return to the original setting

Either of these will close the **Preferences dialogue**.

- **Apply** button to suspend the closing of the **Preferences dialogue** but save the settings if one needs to move to other Tabbed dialogues to change further settings.

The Items chosen and changed from any of the Preferences Tab dialogue will remain with the operating system (for a specific user) until changed.

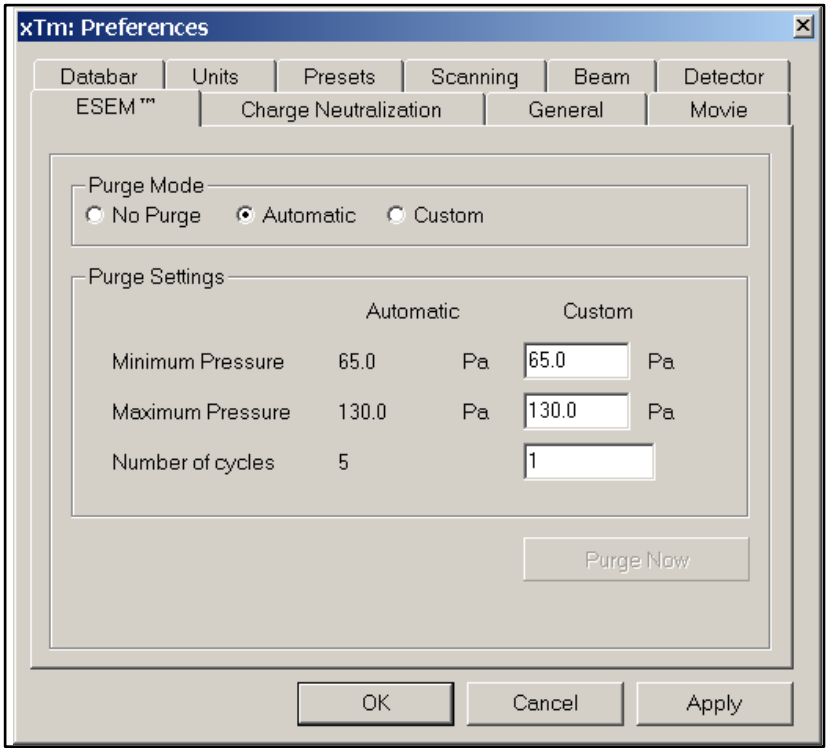
TABLE 5-26 TABBED PREFERENCES

Tab	Settings
ESEM	Purge Mode: No Purge / Automatic / Custom, Purge Settings
Charge Neutralization	High Voltage / Spotsize / Defocus / Source Shift
General	Setting of various behaviour of the user interface
Movie	Set-up for Movie parameters
Databar	Selection of items for entry on the Databar
Units	Selection of units for the system to operate under for Pressure / Temperature / Measurement
Presets	Select and change entries to High Voltage / Spotsize / Magnification / Pressure
Scanning	Selection of presets for the scan speed defaults for Snapshot / Photo / Fast / Slow scan
Beam	Selection of beam operating conditions
Detector	Selections for Custom Detector modes

ESEM TAB

displays the capability to change conditions in the **Purge Mode** (the default condition is **Automatic)**. The **Purge Settings** will reflect the internal pressure and cycle settings depending on the mode selected in the Purge Mode dialogue.

FIGURE 5-28 ESEM PREFERENCES



There may be certain applications (e.g., working with the optional Peltier stage) where the operator needs to change the purge parameters seen above.

Click on **No Purge** when purging of the sample chamber is not desired during Low Vac or ESEM operation. With no purge cycle initiated the chamber will go to the set pressure directly and the gas mixture in the chamber will slowly change to the new gas type. The **Purge Settings** will be greyed out.

Click on **Automatic** will use pre-defined values for **Number of cycles** and **Pressure limits** based on the PLA size. The **Purge Settings** will display the system default values. The following defaults (TABLE 5-27) apply specifically to the Automatic mode.

Click on **Custom** to be able to change the pressure limits (**Minimum Pressure, Maximum Pressure**) and the **Number of cycles** within the **Edit boxes**. The default values for Custom mode are the same as the Automatic mode and are shown in the Edit boxes when first opened. Enter new values in using the keyboard and thereafter press the **Apply** or **OK** button to make them valid.

Purge button is enabled in Low Vacuum or ESEM mode. Pressing on this button starts purging. When purging the button is yellow and pressing on stops the purge.

TABLE 5-27 DEFAULT PURGING SETTINGS FOR DIFFERENT PLA SIZES

PLA size [µm]	Minimum Purge Pressure [Torr / Pa]	Maximum Purge Pressure [Torr / Pa]	Number of cycles
NONE	0.5 / 67	1 / 134	5
1000	1 / 134	5 / 660	5
500	1 / 134	10 / 1340	2
300	1 / 134	10 / 1340	2

The maximum allowed pressure depends on the PLA and the gas type. If the **Maximum pressure** defined for **Custom** is higher than allowed with the current PLA size, the pressure should be reduced automatically to the maximum allowed. No warning is given to the user when this happens; instead the **Preferences / Presets** (see below) dialogue, where the Custom values are entered, warns the user of this possibility in the **Tool-Tips** for the maximum value edit control.

System Behaviour

When you set a new purge condition and press **OK** / **Apply** button:

- If the chamber is not being purged, no action is undertaken,
- If a purge procedure is active, it will immediately change to the new parameters, both pressure and number of purge cycles,
- Active purge cycle can be aborted by selecting **No Purge** radio button.
- If a new auxiliary gas type is selected during purge procedure is active, the new gas type will be used the next time the microscope is pumped to either Low Vac or ESEM.

When pressing **Purge** button purging starts from that point on with the parameters selected active onscreen:

- **No purge**: nothing happens
- **Automatic**: starts purging with automatic settings
- **Custom**: starts purging with custom valid values (do not forget to press Apply after setting new values, otherwise purging starts with old values)
- **Purging is running:** stops purging immediately

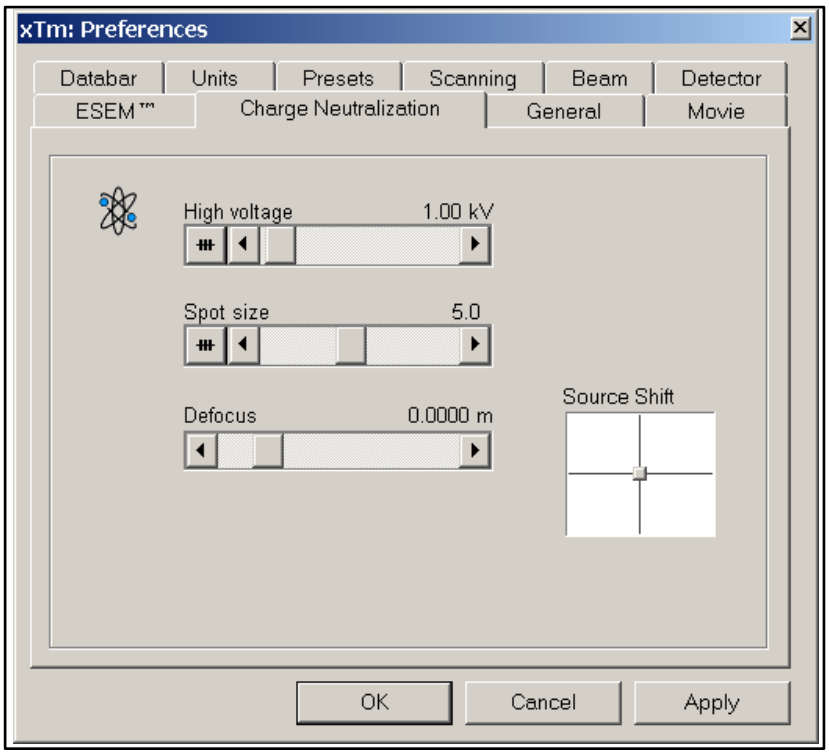
Note:
Purging can take several minutes, according to Preferences setting. Wait until Vacuum status indicates **Vacuum**, because detectors does not start operation until that.
Purge mode changes from **No Purge** to **Automatic** after inserting LFD, so the user does not need to remember. This eliminates arching due to improper / insufficient purge.

See Chapter 3 “Vacuum” for more details.

CHARGE NEUTRALIZATION TAB

sets conditions for the Charge neutralization mode, which can be switched on in the **Electron Beam Current** module on the Beam Control page by pressing the **Neutralize** button (see Chapter 4).

FIGURE 5-29 CHARGE NEUTRALIZATION PREFERENCES



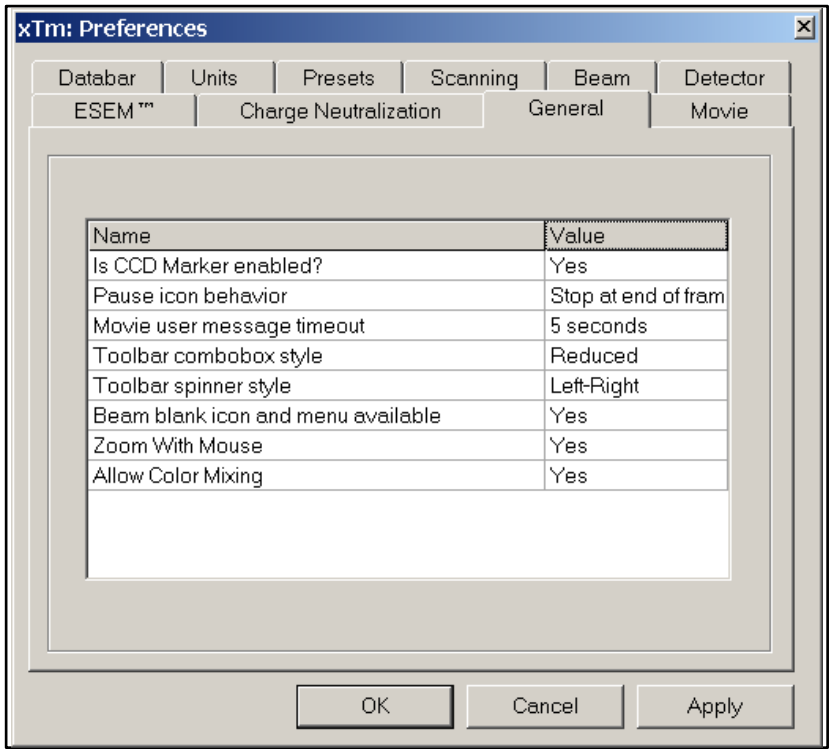
There are following Control Adjusters:

- **High Voltage**
  sets the electron beam voltage used for charge neutralization. Start with 1 - 2 kV.
- **Spotsize**
  sets the electron beam spotsize (current) used for charge neutralization to specific values from 1 to 10. The larger the spotsize number the larger the beam diameter (higher the beam current).
- **Defocus**
  defines the iluminated area used for charge neutralization. During Charge Neutralization the electron beam does not scan. At defocus diameter the spot is focused. Start with maximum negative value.
- **Source Shift**
  shifts the electron source alignment. Use it to maximize beam current at a very high spots (>8).

GENERAL TAB

allows setting of various behaviour of the user interface. Clicking on any value field causes combo button appearing to list available values and to choose one.

FIGURE 5-30 GENERAL PREFERENCES



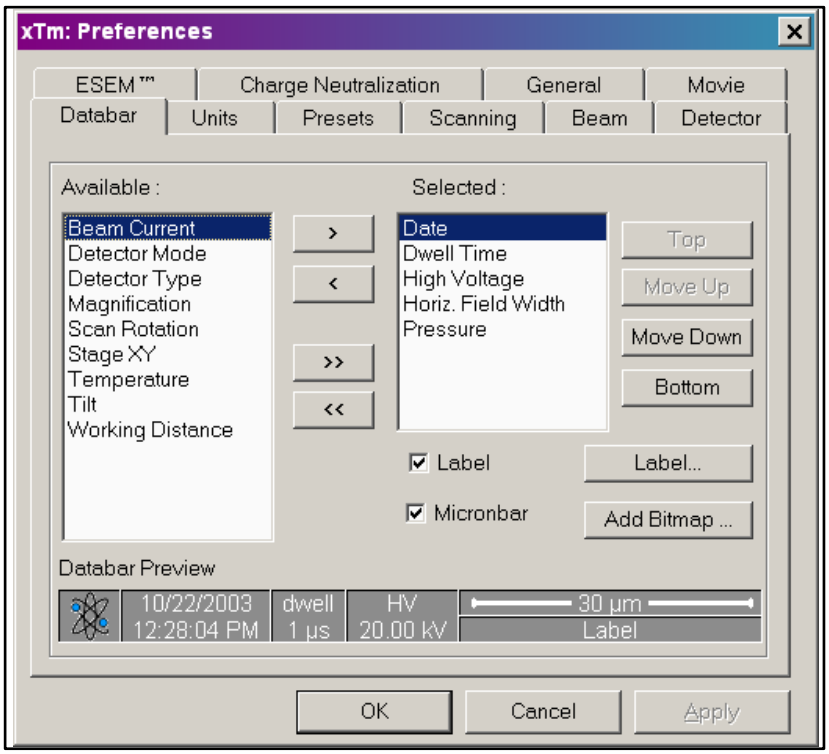
Description and possible Values are:

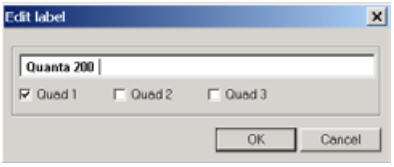
- **Is CCD Marker enabled?** (Yes / No)
  enables visualization of the marker to the eucentric distance in optical image.
- **Pause icon behavior** (Stop at end of frame / Stop immediately)
  The scanning will stop immediately after pressing the Pause icon or after finishing the frame.
- **Movie user message timeout**
  (Don´t display / 1 second / 2 seconds / 5 seconds / 30 seconds)
  specifies how long the information about just started movie lasts on screen
- **Toolbar combobox style** (Reduced / Standard)
  specifies a type of the comboboxes in the toolbar
- **Toolbar spinner style** (Left-Right / Up-Down)
  specifies type of the Dwell time spinner in the toolbar
- **Beam blank icon and menu available** (Yes / No)
  switches accessibility of the beam blank option
- **Zoom With Mouse** (Yes / No)
  enables the drag and zoom option for magnification and/or stage moves
- **Allow Color Mixing** (Yes / No)

DATABAR TAB

specifies content of the databar at the base of the imaging screen or screens. There are two lists, one labelled **Available** and the other **Selected**. Items in the Available list can be added / removed individually (**>** / **<**) or as a whole (**>>** / **<<**) to / from the Selected list. The Selected list when completed contains all items that will be displayed in the DataBar. The order of the items in the Selected list can be **Moved Up**, **Moved Down**, **Top** or **Bottom** due to priority or preference. This will in turn change the order of the displayed items in the DataBar. The chosen Items remains with the operating system until changed.

FIGURE 5-31 DATABAR PREFERENCES





The **Label** and **Micronbar** could be chosen by checking the appropriate box and their area expands or contracts together to accommodate other items added to the DataBar.

Clicking the **Label...** button a choice dialogue appears to edit and copy the label to any of the other quads.

Clicking the **Add Bitmap...** button opens a dialog to load a bitmap into the databar.

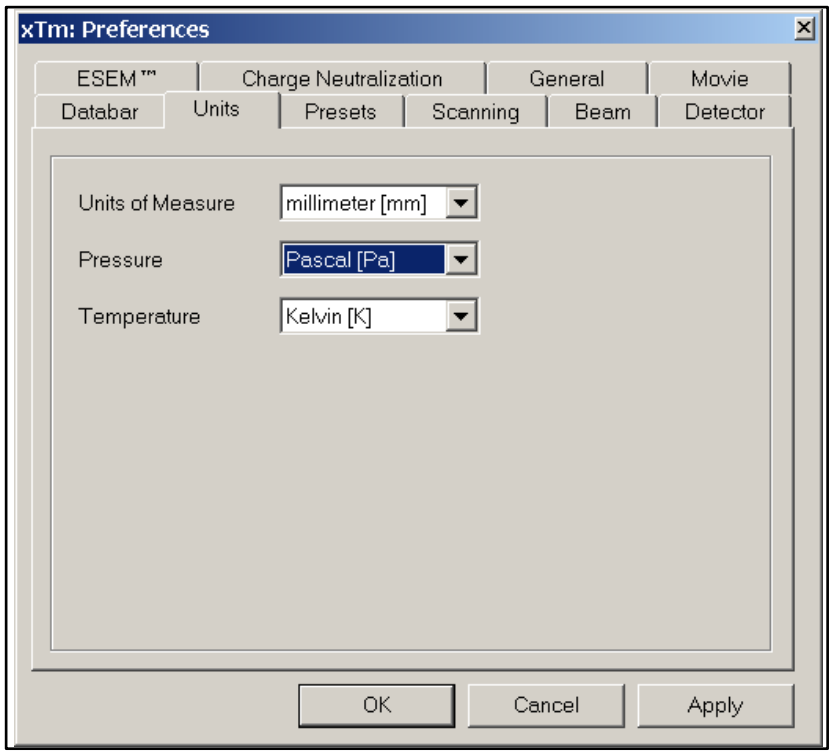
Description for the other items is simply appreciable from it´s designation.

Note:
The limit for entries is displayed in the dialogue as it is updated. It is possible to select more items than could be displayed. Databar preview should be used to check available space.

UNITS TAB

displays the capability to change the units for pressure, temperature and measure. Selection can be made by clicking on the list arrow and consecutively clicking on the desired unit. The choices affects the stage dialog / input boxes, the databar display, the status module dialogs etc. The chosen units remains with the operating system until changed.

FIGURE 5-32 UNITS PREFERENCES



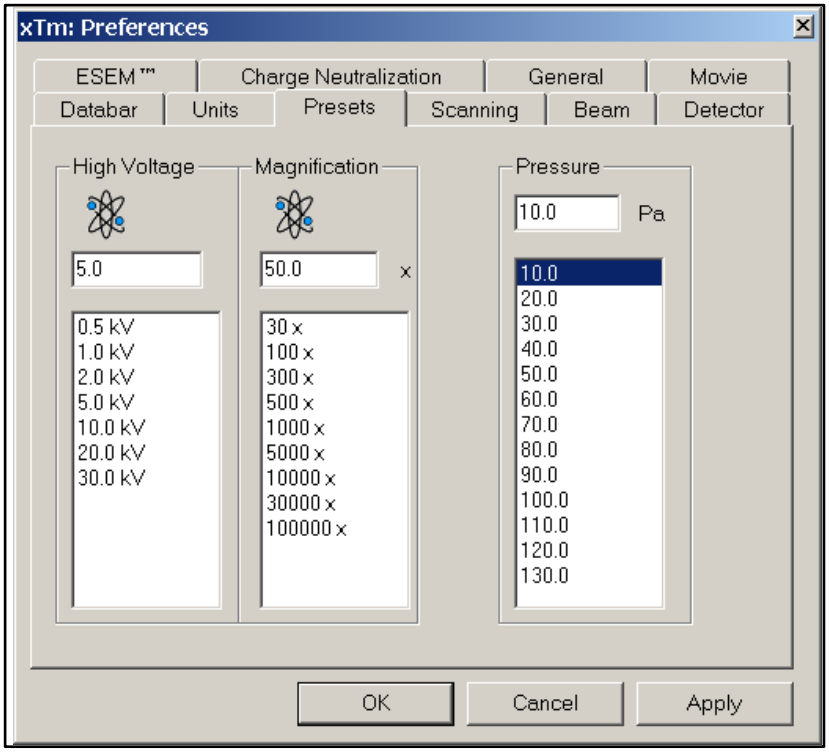
Selection posibilities are:

- **Units of Measure:** Meter / Millimetre / Inch / Foot
- **Pressure:** Pascal / Torr / Bar
- **Temperature:** Kelvin / Celsius / Fahrenheit

PRESETS TAB

displays the capability to change values in the High Voltage, Spotsize, Magnification and Pressure ranges either the Electron or Ion column. Either single or numerous values can be inserted in the lists. Changing values can be accomplished by selecting a value in the list to edit and entering new values in the edit box just below the respective title. The entered values remain with the operating system until changed.

FIGURE 5-33 PRESETS PREFERENCES



The **High Voltage** list can be changed to span any values from 200V to 30kV. As the values are displayed in Volts the entry value in the edit box can be specific in value.

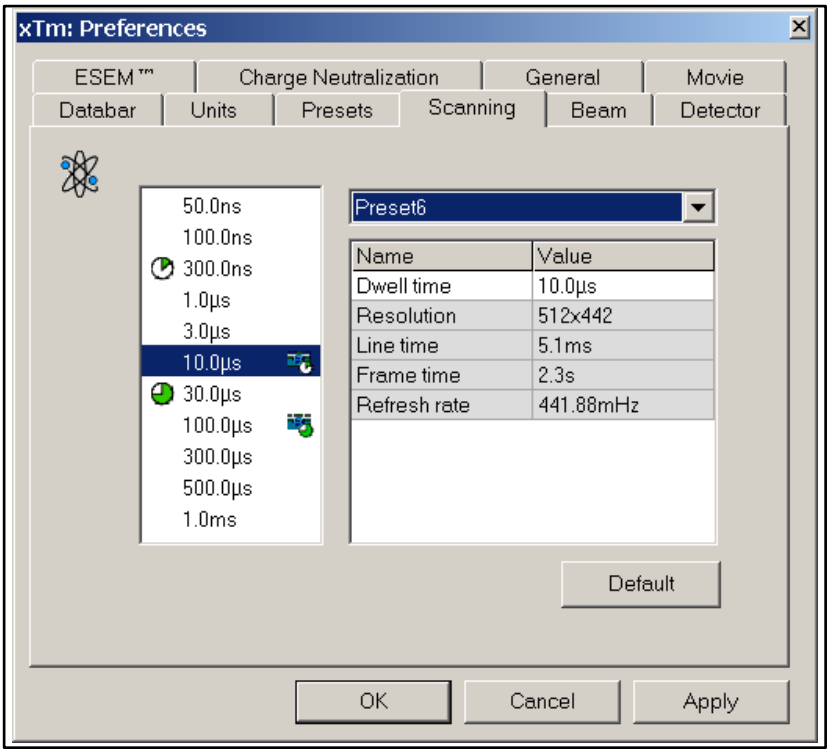
The **Magnification** list can be changed to hold regular used values or general values. Magnification values that are in the list but do not apply because of the Working distance condition will be greyed out in the Magnification menu on the Menu Bar. Magnification range is from 10x to 300 000x.

The **Pressure** list can be changed to hold specific values regularly used in the Low Vac and ESEM modes.

SCANNING TAB

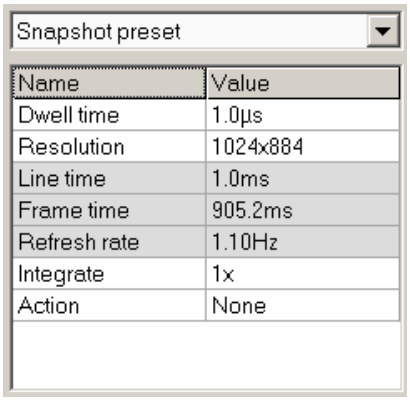
displays the capability to change scan times table and make presets to the Slow / Fast / Snapshot scan buttons on the toolbar and for the Photo function also.

FIGURE 5-34 SCANNING PREFERENCES



On the left of the dialogue box there is a **Dwell-time preset** list with a fixed number of entries (11). There are two icons which correspond to the 'Slow' and 'Fast' preset buttons on the toolbar and two ones which corresponds to the Snapshot and Photo functions indicating the relevant dwell-time value. To change these values move any icon up or down just by clicking-and-draging it. The Default button restores the default list and icon positions.

By selecting an entry it can be changed in the Dwell Time line of the Property Editor on the right side of the list. This works also for the Fast and Slow icons which are for selecting scan speeds only.



Scan Preset

The Snapshot and Photo icons are dedicated to capture images at given scan conditions, which are adjustable for appropriate Scan preset selected from the dropdown menu. There are also many of the user presets to set. (Some of the lines are Non-Editable under some conditions.)

- **Dwell Time:** one point beam duration time
- **Resolution:** No. of points on Width x Height (screen resolution)
- **Line Time:** line scan duration time (Non-Editable)
- **Frame Time:** screen scan duration time (Non-Editable)
- **Refresg Rate:** screen refresh frequency (Non-Editable)
- **Integrate:** No. of integrated frames (1, 2, 4, 8, 16, 32, 64, 128, 256)
- **Actions** activated at the end of Snapshot / Photo functions**:**
  Save prompts the dialog and displays the next increment with the last set-up or used folder location.
  Save As... prompts the dialog for the user to choose the file name and location.
  None - no save function, just a screen image.

Scan Operators

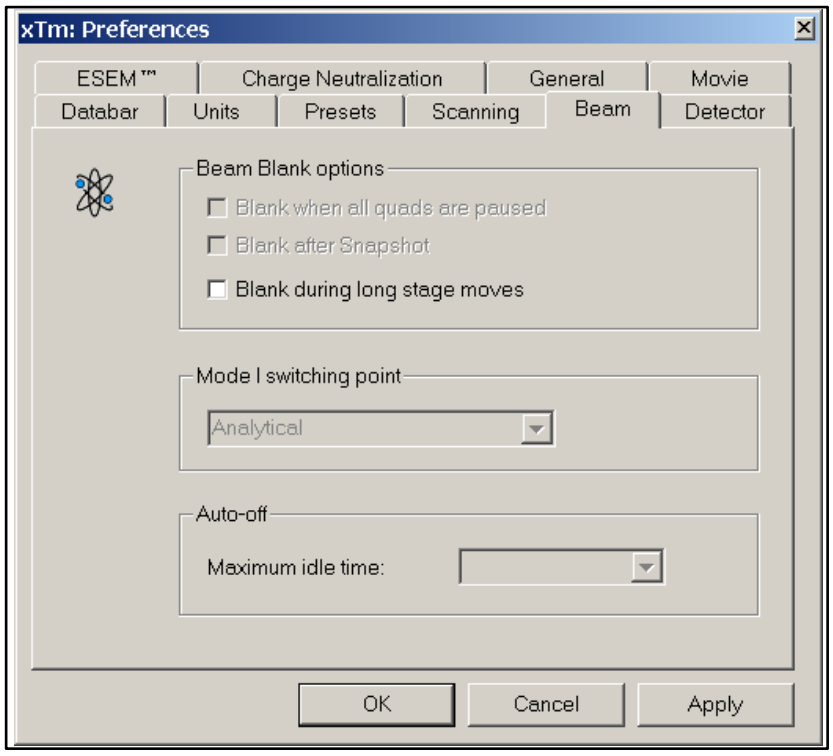
- **The Fast icon:** Fast Scan in the Scan Preset dropdown list.
- **The Slow icon:** Slow Scan in the Scan Preset dropdown list.
- **The Flash Camera:** Snapshot in the Scan Preset dropdown list.
- **The normal Camera:** Photo in the Scan Preset dropdown list.
- **User Preset:** Can be chosen by the user from the dropdown list.

Each of these scan operators has its own list of property editors below the main dropdown top box so that changes can be made.

BEAM TAB

Beam Blanking may be necessary for either beam during a session. The following conditions can be set by ticking the check boxes:

FIGURE 5-35 BEAM PREFERENCES



Beam Blank Options

- **Blank when all Quads are paused:** not available for Quanta 3D.
- **Blank after Snapshot:** not available for Quanta 3D.
- **Blank during long stage moves**
  blanks the beam during long movements across a sample to prevent any effect from either beam on the surface of the sample.

Mode 1 Switching Point

Not available for Quanta 3D.

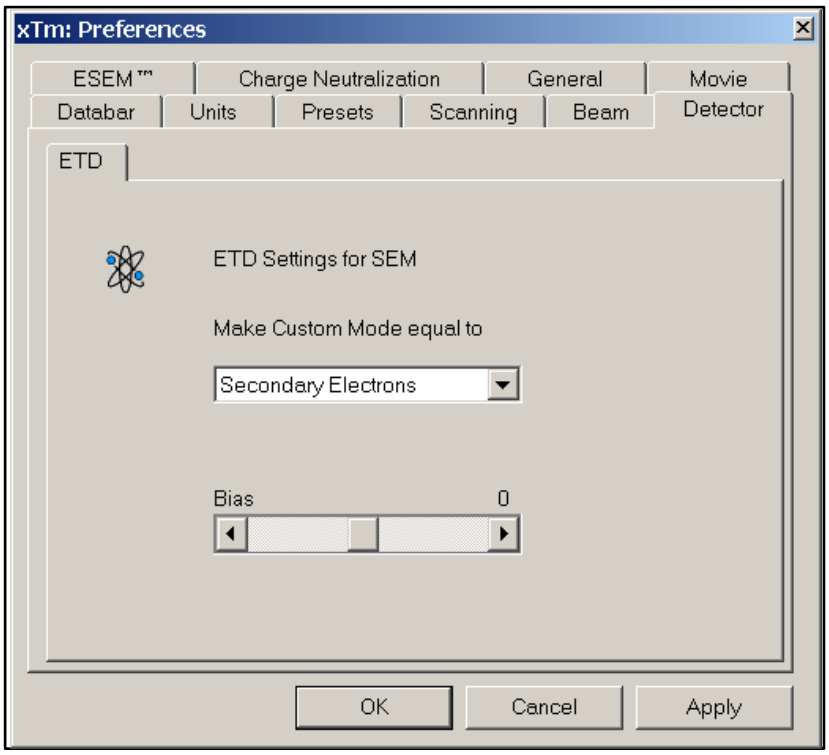
Auto Off

Not available for Quanta 3D.

DETECTOR TAB

displays specific active (for the Quad in use) detector menu. Those detectors that have a Custom mode will have a Preferences dialog for adjustment. For settings see particular detector instructions.

FIGURE 5-36 DETECTOR PREFERENCES



MOVIE TAB

provides two groups one to choose set-up conditions for timing labelled **Timer**, and the other to set-up save conditions for the resultant movie labelled **File**.

See chapter Recording Movie on page 5-46 for detailed description.

6 ALIGNMENTS

OVERVIEW

This section describes the set-up for source and column for both beams (Ion and Electron), e.g. the emitter start, the proper final lens alignment, the proper saturation of the filament and the electronic alignment of the columns using the software in the “Alignments” Pages.

Recommendation - Electron Column

Total alignment of the system should be made whenever necessary (or on a fixed interval schedule) in the following order:

- 9 - Filament Exchange
- 2 - Tetrode Alignment (column)
- 3 - Gun Alignment (column)
- 4 - Condenser Alignment (column)
- 5 - Final Lens Alignment (column)
- 6 - Stigmator Alignment (column)
- 7 - Stage Rotation centre (Stage alignment only)
- 8 - PLA Centering (column)

The above column alignments should only be attempted when the column has been misaligned by being opened for cleaning or repair. The correction of only one procedure may influence others, therefore care should be taken to monitor the influence of actions taken. Typical events need correction by the following sequence of alignments:

- Final lens aperture change: **5 / 6**
- Filament exchange: **9**
- Tetrode cut-off: **2** / **3**
- Column liner clean or other column disturbance: **9** / **2** / **3** / **4** / **5** / **6**
- Whenever necessary: **6** / **7** / **1**

Recommendation - Ion Column

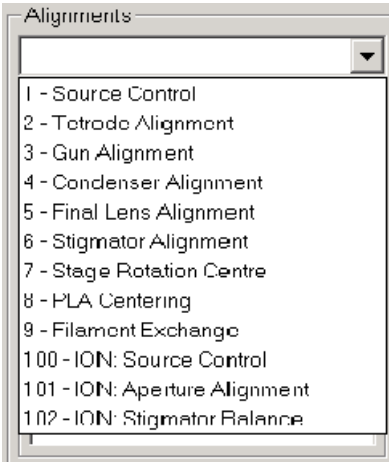
The Ion column does not require any regular alignment.

The procedure **100 -ION: Source Control** should be executed when:

- Emergency / Power Off: to start the IGP or to pump the ion column
- Ion source does not start / spontaneously switches off: to manually start the heat procedure

The procedures **101 - ION: Aperture Alignment** and **102 - ION: Stigmator Balance** can be used for fine tuning the ion column. It is recommended to check the **101** for HV 30 kV at probe currents >50 pA to ensure the proper performance of the Auto TEM script.

Quanta 3D Systems Alignments


Alignments
1 - Source Control
2 - Tetrode Alignment
3 - Gun Alignment
4 - Condenser Alignment
5 - Final Lens Alignment
6 - Stigmator Alignment
7 - Stage Rotation Centre
8 - PLA Centering
9 - Filament Exchange
100 - ION: Source Control
101 - ION: Aperture Alignment
102 - ION: Stigmator Balance

Go to the “Alignments” pages. Open the list box by clicking on the down arrow, then choose the **Alignment** needed. Always follow the instructions given in the **Instructions** module. Click on the **Start** button and proceed with following pages.

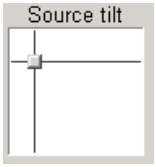
Before you align the Electron column, be sure that the final lens aperture is clean and properly seated. All alignment procedures should be operated in a fast scan mode.

Note:
Some alignment pages contain control adjusters for contrast and brightness. The contrast and brightness adjusters of the electron beam are connected to the imaging quad 1, while contrast and brightness of the ion beam are connected to the imaging quad 2. To ensure the correct functionality of the sliders, always use imaging quad 1 for the electron column alignments (procedures 1–9) and imaging quad 2 for the ion column alignment (procedures 100–102).

TABLE 6-1 ALIGNMENT PROCEDURES OVERVIEW

Procedure	Function
1 - Source Control	Filament setting and electron gun centering.
2 - Tetrode Alignment	This alignment is for centering gun shift and tilt relative to the tetrode to give maximum illumination, especially at low voltages.
3 - Gun Alignment	Correction of gun shift for the whole range of the accelerating voltages and high spotsizes. This optimizes the brightness and field of view at high beam currents.
4 - Condenser Alignment	Dual correction of the accelerating voltage levels and spotsize range. This is achieved by moving a pre-determined object back under the centre cross at different kVs and spotsizes. This eliminates excessive image movement when changing accelerating voltage or spotsize under normal use.
5 - Final Lens Alignment	Objective lens coil modulation (wobbler) to show the optical centre of rotation. X and Y are used to bring the rotation centre under the cross in the screen centre. This eliminates image shift when focusing.
6 - Stigmator Alignment	X and Y correction of each X and Y stigmator. Minimises the movement seen in both X and Y procedures to eliminate image shift during normal stigmator correction.
7 - Stage Rotation Center	Corrects the center of rotation at any point on the specimen by computer correction of the X, Y offset from the stage mechanical center.
8 - PLA Centering	Corrects the center of the projected PLA aperture to the center of the display screen at low magnification.
9 - Filament Exchange	Filament exchange procedure.
100 - ION: Source Control	Used for: ion source starting and heating, IGP starting after any shutdown state.
101 - ION: Aperture Alignment	Exhaustively adjusts Ion column for all voltages and beam currents. This eliminates image shift and defocus when changing HV and/or beam current.
102 - ION: Stigmator Balance	Minimises the movement seen in both X and Y procedures to eliminate image shift during normal stigmator correction.

TIPS FOR X AND Y CORRECTIVE MOVEMENT



Alignments 4, 6, 8 and 101 all require some corrective movements, but this is simplified by X and Y being represented as a 2D Graphical adjuster. When the 2D control is clicked on, and the left-hand mouse button is held in, a cross-hair shows on the screen with a small four-ended arrow cursor located in the center. Moving the mouse causes the cross-hairs to move and therefore affects the image as required. Due to the fact that the image rotation correction is switched off automatically in some alignment procedures the X and Y movements may not always appear to be in the same directions.

Note:
Do not use the Beam Shift at any time during the adjustment procedures, other than where specified, as this is set to zero value at each alignment section, and extra movement can offset the zero condition. All movement of the specimen can be made using the stage, either mechanical or motor driven, where appropriate.

COMMON BUTTONS BEHAVIOUR

The following buttons and behaviours are common for all alignment pages. When available, they have the following effects:

- the **Next** button moves the user to the following page after all the necessary settings have been selected.
- the **Previous** button moves the user to the previous page should a previous setting need to be changed.
- the **Finish** button completes the procedure and saves the new settings.
- the **Save** / **Store** button saves the actual settings at that point.
- the **Cancel** button (at any time) is different for particular alignments:

  1) It returns to the start without having changed the original settings.

  2) It stops the alignment procedure, but does not restore any conditions that have been changed by clicking the Save / Store button.

1 - Source Control

Source Control is used for the fine tuning of source tilt conditionally on HV, resaturation of the filament after a few hours of operation and for special setting of the emission.

1. Select the electron beam in the imaging quad 1. Press the **Start** button.

To readjust the filament saturation for current HV or the whole range:

2. Press the **Xover** button to get the crossover image.
3. Tune the **Filament Voltage**.
4. Click on the **Store** button if you would like to store the new Filament Voltage for the entire High Voltage range. If the Store button is not used the Filament Voltage returns to the previous value after leaving this alignment page.
5. Press the Xover button to return to normal imaging mode.

To optimize the source tilt:

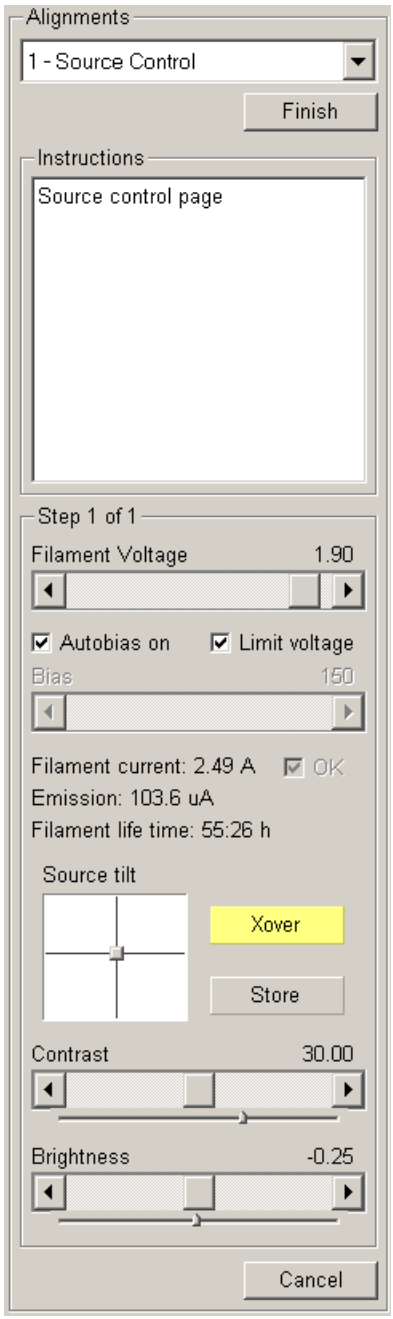
2. Select the HV which should be optimized.
3. Tune the **Source Tilt** to achieve maximum image brightness.
4. Press the **Store** button to save the Source Tilt setting for current HV.
5. Optionally repeat this procedure for others HV.

To change the emission current:

2. Select the HV which will be used.
3. Uncheck the Autobias on checkbox, the Bias slider is enabled.
4. Set the required emission current with the Bias slide.
5. Readjust the filament saturation as described above.

Note:
It is not recommended to operate the electron gun with Autobias off permanently. This feature can be used to temporally change the emission current, either to enhance the brightness of the gun (higher emission current) or to reduce filament heating for longer filament lifetime at long term acquisitions (such as EDX mapping).

DESCRIPTION OF CONTROL ELEMENTS



- **Filament Voltage** control regulates the voltage feed to the filament to create saturation.

  C a u t i o n !

  Care should be taken not to oversaturate the tungsten filament. If the image loses brightness as the voltage is increased then the Source Tilt 2D control may need correction until maximum brightness and stable filament current have been achieved.
- **Limit Voltage** check box limits the currently set Filament voltage value when checked.
- **Bias** control regulates the emission current. In the Autobias On mode (checked) the adjuster shows the relevant Auto setting and it is greyed.
- **Autobias On** check box allows the user to set the Bias value shown at the right side of the adjuster when not checked.
- **Filament Current** shows current (A) used for the filament heating. If this is zero at non-zero filament voltage, the filament may be blown and must be replaced. This condition is indicated by an unticked **OK** checkbox next to the Filament current value.
- **Emission** shows the electron beam emission current (µA). When the Autobias On is checked, the emission should be approximately 100 µA.
- **Filament Lifetime** is a timer for recording filament hours.
- **Source Tilt** 2D control indicates the actual setting of the electronic Gun Tilt with respect to its extreme settings. It changes the effective angle of illumination of the beam coming from the gun area of the electron column.

  Use it to manually centre the illumination (maximize beam brightness). Clicking with the mouse on the source tilt area causes a four-ended cross cursor to be shown on the full screen or quad. Move the cursor left / right and up / down to control the source tilt X and Y. If finer tilt is required, use the logarithmic capabilities of the 2D control (explained earlier in this chapter). The actual position of Source tilt is always shown by the position of the crosshair in the X-Y control.
- **Xover** button allows imaging of the tip and is useful during the alignment procedure. It is available only when the system is in operation.

  Note:

  If the **Source tilt** is severely misaligned, the image of the crossover can be also very helpful. The crossover is visible in slow scan mode, and to help, the centre of the screen is marked with a cross. The crossover should be in close vicinity to the cross. It can be set to the correct position by manipulation of the Source tilt. If, in this condition, the crossover mode is switched off, a normal scanned image will appear on the screen.
- **Store** button is used to store the Filament voltage.
- **Contrast / Brightness** adjuster allows the user to control the image quality.

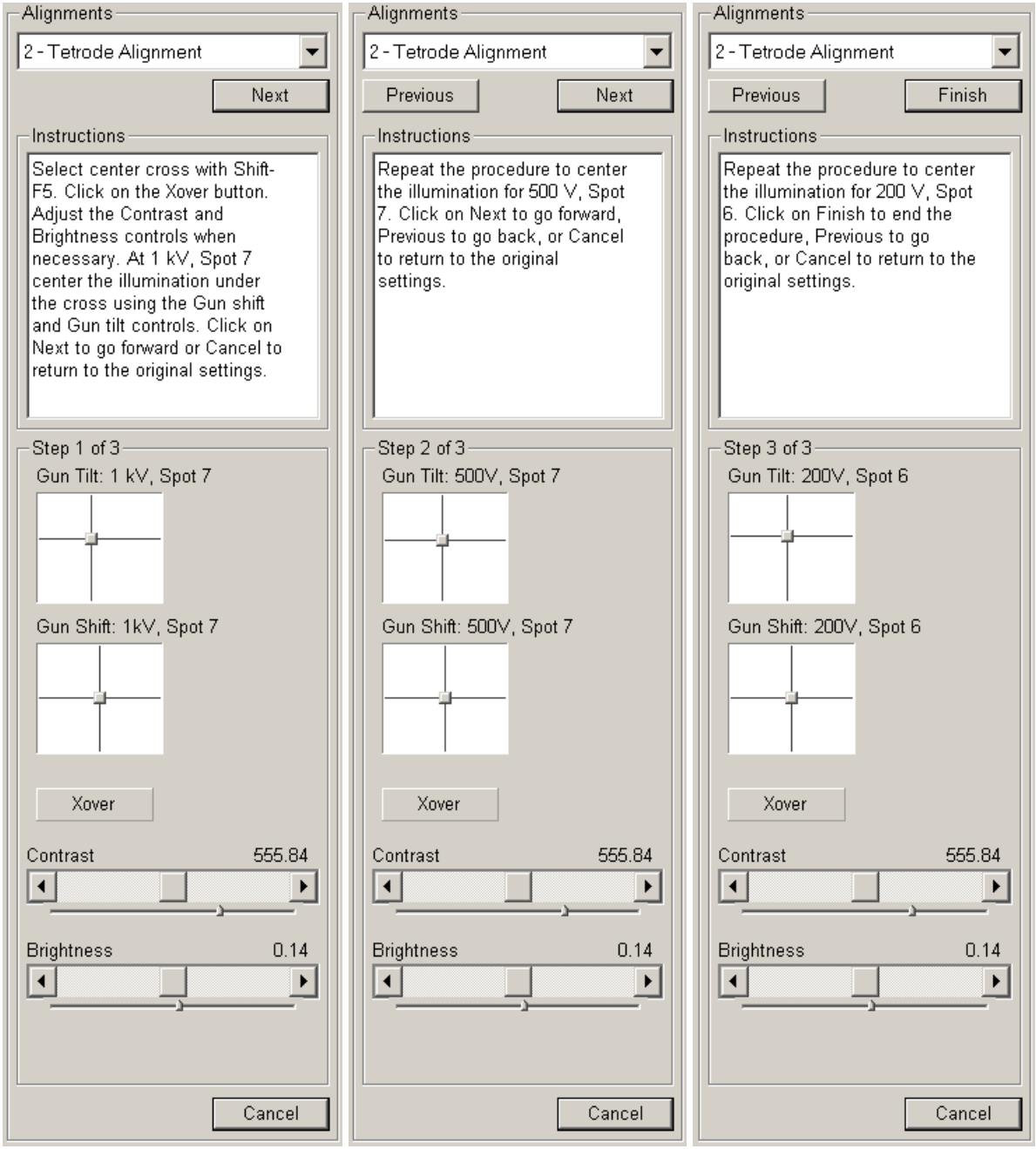
2 - Tetrode Alignment

Alignments
2 - Tetrode Alignment
Start
Instructions
This Alignment is for centering the Gun shift and Tilt relative to the Tetrode to give maximum illumination especially at low voltages. Press the Start button.
No step

Tetrode Alignment aligns the Gun Tilt and Shift to optimise the source illumination through the Tetrode, especially at low voltages.

1. Click on the **Xover** button.
2. Adjust the **Contrast** and **Brightness** adjusters if necessary.
3. At 1kV, Spot 7 centre the illumination under the **Centre Cross** and remove the cutoff using the **Gun Tilt** and **Gun Shift** 2D controls.
4. Repeat the procedure to centre the illumination for 500V, Spot 7.
5. Repeat the procedure to centre the illumination for 200V, Spot 6.

Tetrode Alignment Pages (continued)


Alignments
2 - Tetrode Alignment
Next
Instructions
Select center cross with Shift-F5. Click on the Xover button. Adjust the Contrast and Brightness controls when necessary. At 1 kV, Spot 7 center the illumination under the cross using the Gun shift and Gun tilt controls. Click on Next to go forward or Cancel to return to the original settings.
Step 1 of 3
Gun Tilt: 1 kV, Spot 7
Gun Shift: 1kV, Spot 7
Xover
Contrast 555.84
Brightness 0.14
Cancel
Alignments
2 - Tetrode Alignment
Previous
Next
Instructions
Repeat the procedure to center the illumination for 500 V, Spot 7. Click on Next to go forward, Previous to go back, or Cancel to return to the original settings.
Step 2 of 3
Gun Tilt: 500V, Spot 7
Gun Shift: 500V, Spot 7
Xover
Contrast 555.84
Brightness 0.14
Cancel
Alignments
2 - Tetrode Alignment
Previous
Finish
Instructions
Repeat the procedure to center the illumination for 200 V, Spot 6. Click on Finish to end the procedure, Previous to go back, or Cancel to return to the original settings.
Step 3 of 3
Gun Tilt: 200V, Spot 6
Gun Shift: 200V, Spot 6
Xover
Contrast 555.84
Brightness 0.14
Cancel

3 - Gun Alignment

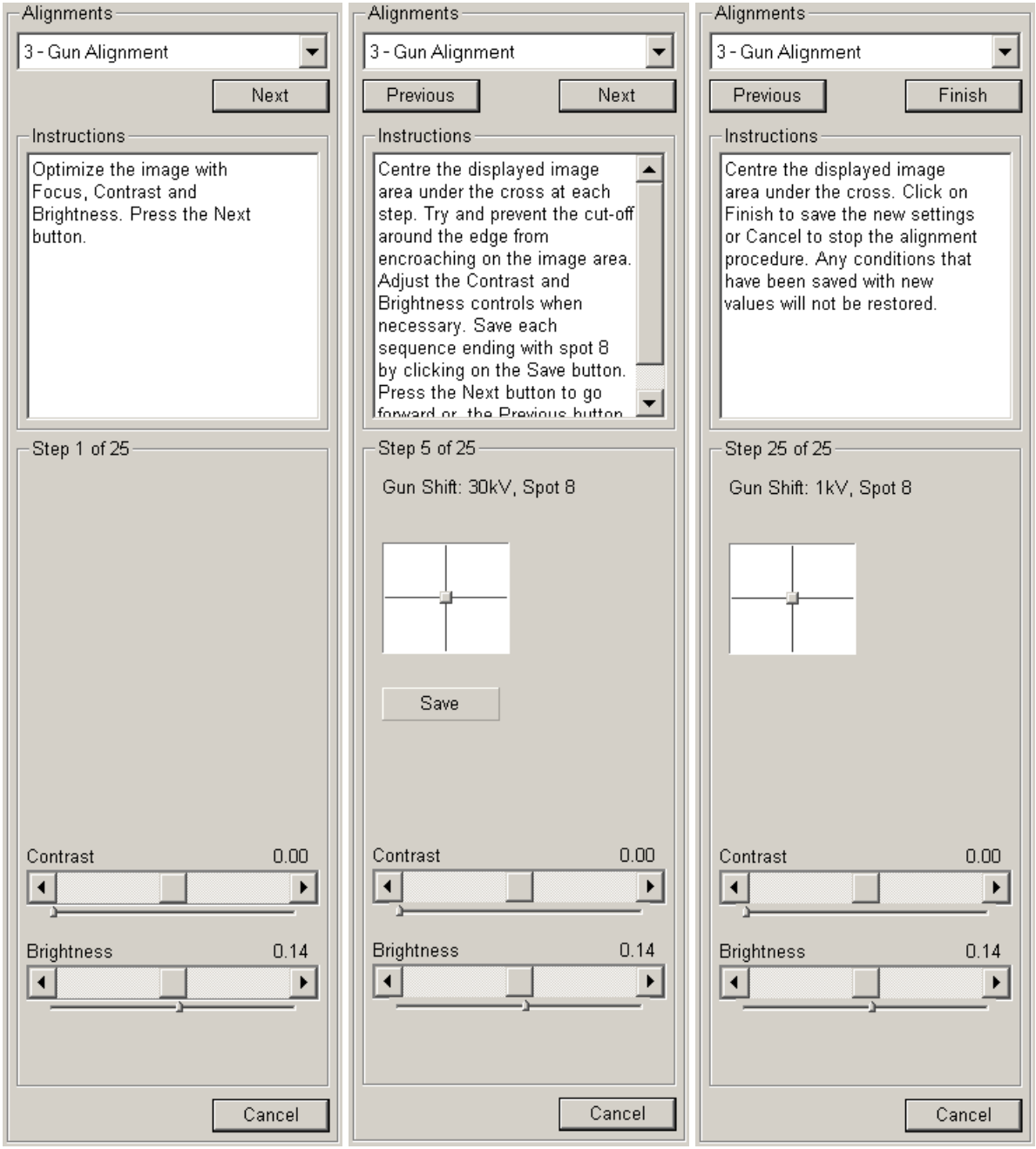
Alignments
3 - Gun Alignment
Start
Instructions
This alignment centers the electron beam for several Spotsizes and High Tensions. Press the Start button.
No step

Gun Alignment corrects the Gun Shift X and Y for beam diameter center to screen center. The illumination circles are centered on a cross displayed at the center of the screen. This procedure electronically aligns the illumination to the mechanical column alignment.

After finishing this procedure the illumination should be centered.

1. Adjust **Focus** and the **Contrast** and **Brightness** adjusters if necessary.
2. Make correction, using the 2D control **Gun Shift**. The procedure corrects alignment through the (30, 20, 10, 5, 2, 1) kV. For each HV Spot: 5, 6, 7, 8 are selected automatically for correction. This results in 24 Steps.
3. The **Save** button appears on every fourth page with spot 8 for every HV, with the exception of **Step 24** which saves the values and finishes the procedure with the **Finish** button. This eliminates unnecessary repetition of all conditions if only one alignment section is not correct.

Gun Alignment Pages (continued)


Alignments
3 - Gun Alignment
Next
Instructions
Optimize the image with Focus, Contrast and Brightness. Press the Next button.
Step 1 of 25
Contrast 0.00
Brightness 0.14
Cancel
Alignments
3 - Gun Alignment
Previous
Next
Instructions
Centre the displayed image area under the cross at each step. Try and prevent the cut-off around the edge from encroaching on the image area. Adjust the Contrast and Brightness controls when necessary. Save each sequence ending with spot 8 by clicking on the Save button. Press the Next button to go
Step 5 of 25
Gun Shift: 30kV, Spot 8
Save
Contrast 0.00
Brightness 0.14
Cancel
Alignments
3 - Gun Alignment
Previous
Finish
Instructions
Centre the displayed image area under the cross. Click on Finish to save the new settings or Cancel to stop the alignment procedure. Any conditions that have been saved with new values will not be restored.
Step 25 of 25
Gun Shift: 1kV, Spot 8
Contrast 0.00
Brightness 0.14
Cancel

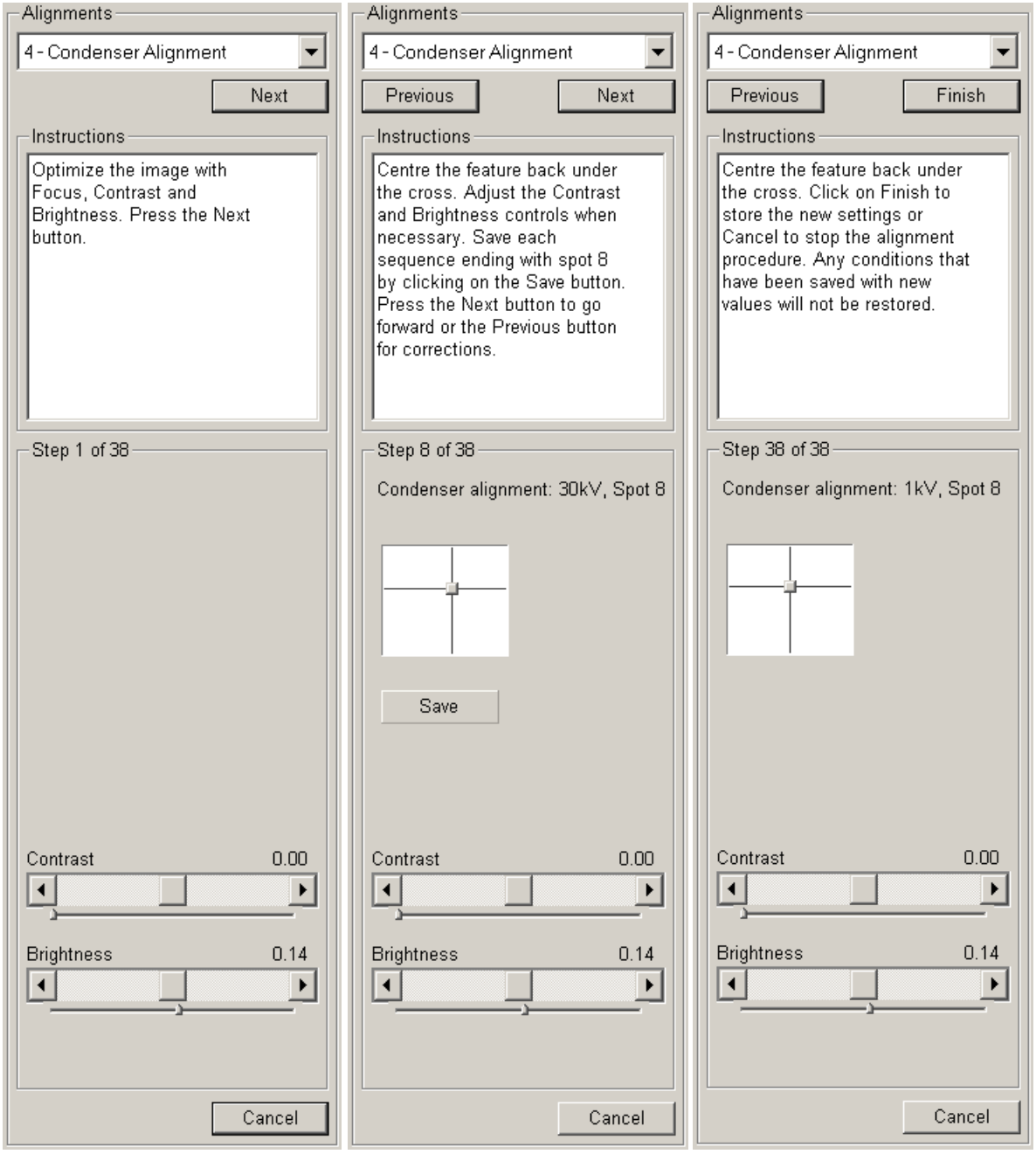
4 - Condenser Alignment

Alignments
4 - Condenser Alignment
Start
Instructions
This Alignment minimizes the image shift under different High Tensions and Condenser settings. Press the Start button.
No step

Condenser Alignment eliminates image shift between different accelerating voltages and different spotsizes by aligning the same image centre of an object at fixed Voltages and spots. Values between the fixed conditions are interpolated from the stored table.

1. Bring a recognisable image feature under the screen **Centre Cross**. This can be done by using the 2D control labelled **Beam Shift** or by using a stage movement.
2. Adjust the **Focus** and the **Contrast** and **Brightness** adjusters if necessary.
3. Make the correction using the 2D control at **Step 1** by bringing the recognisable image feature back under screen Centre Cross. The procedure corrects alignment through the (30, 20, 10, 5, 2, 1) kV. For each HV Spot: 6, 5, 3, 1, 7, 8 are selected automatically for correction. This results in 36 Steps.
4. The **Save** button appears on every sixth page with spot 8 for every HV, with the exception of **Step 36** which saves the values and finishes the procedure with the **Finish** button. This eliminates unnecessary repetition of all conditions if only one alignment section is not correct.

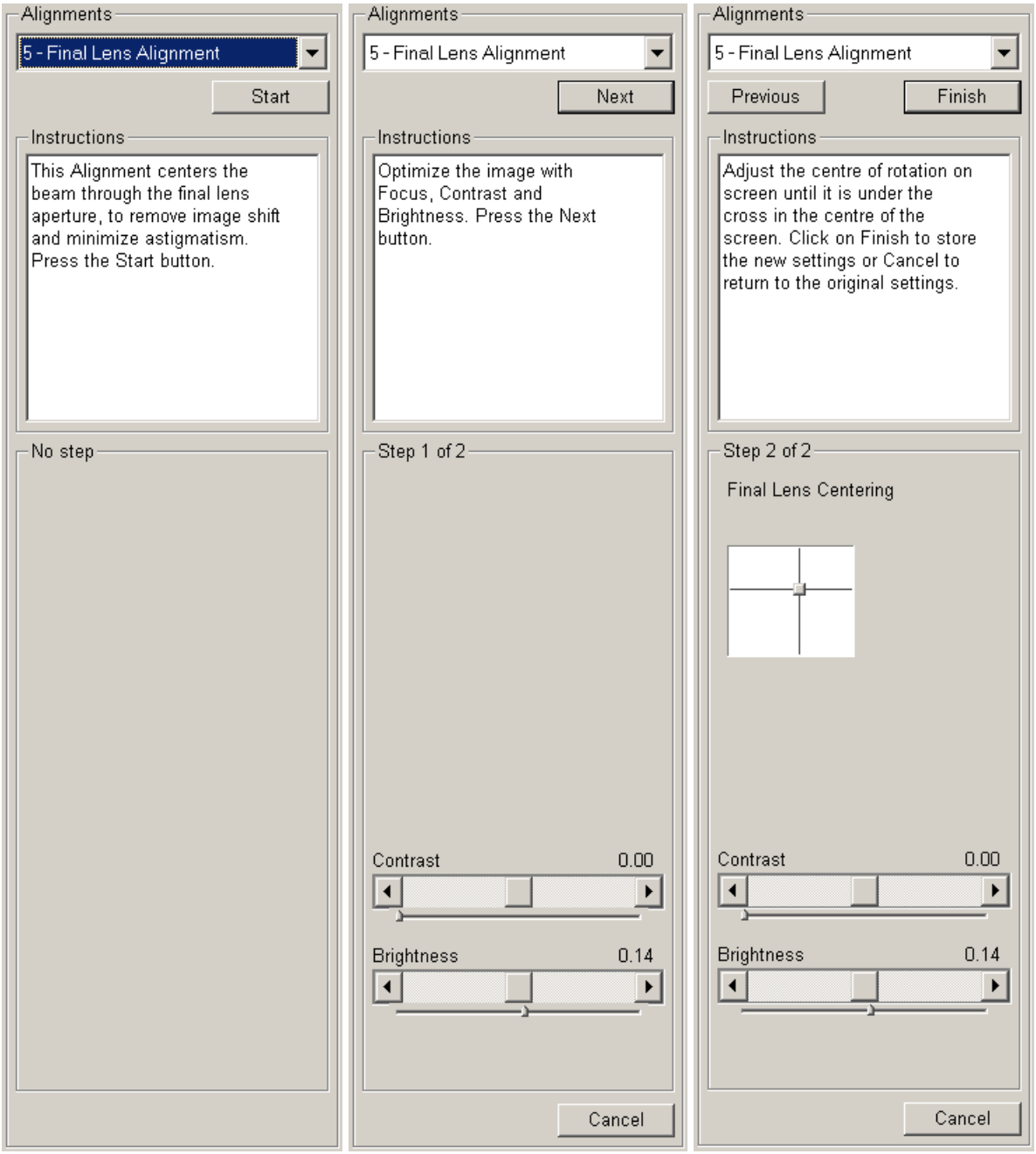
Condenser Alignment Pages (continued)


Alignments
4 - Condenser Alignment
Next
Instructions
Optimize the image with Focus, Contrast and Brightness. Press the Next button.
Step 1 of 38
Contrast 0.00
Brightness 0.14
Cancel
Alignments
4 - Condenser Alignment
Previous
Next
Instructions
Centre the feature back under the cross. Adjust the Contrast and Brightness controls when necessary. Save each sequence ending with spot 8 by clicking on the Save button. Press the Next button to go forward or the Previous button for corrections.
Step 8 of 38
Condenser alignment: 30kV, Spot 8
Save
Contrast 0.00
Brightness 0.14
Cancel
Alignments
4 - Condenser Alignment
Previous
Finish
Instructions
Centre the feature back under the cross. Click on Finish to store the new settings or Cancel to stop the alignment procedure. Any conditions that have been saved with new values will not be restored.
Step 38 of 38
Condenser alignment: 1kV, Spot 8
Contrast 0.00
Brightness 0.14
Cancel

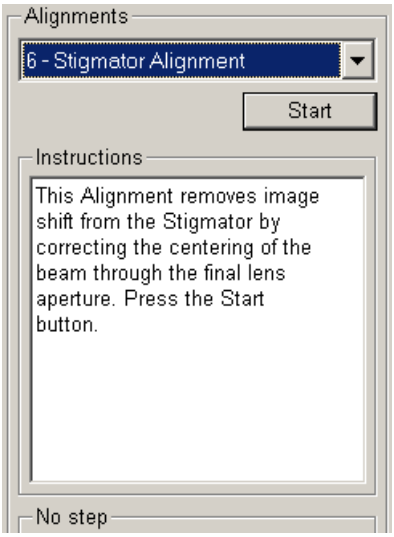
5 - Final Lens Alignment

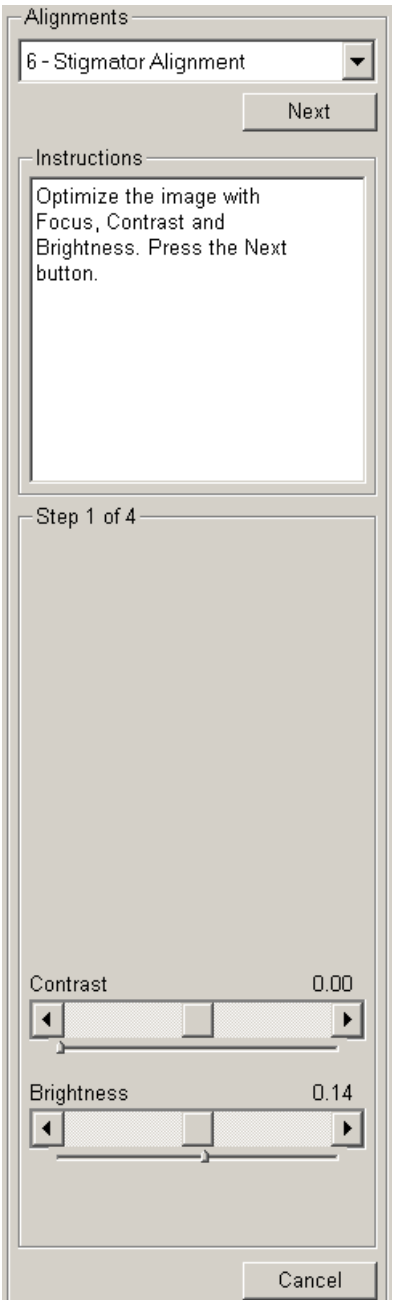
Final Lens Alignment aligns the beam through the objective aperture.

1. Adjust **Focus** and the **Contrast** and **Brightness** adjusters if necessary.
2. The image starts modulating (alternately rotating clockwise and counter-clockwise). The rotation centre of the image indicates the required position. Locate the rotation centre under the screen **Centre Cross** by using the **Final Lens Centering** 2D control control.


Alignments
5 - Final Lens Alignment
Start
Instructions
This Alignment centers the beam through the final lens aperture, to remove image shift and minimize astigmatism. Press the Start button.
No step
Alignments
5 - Final Lens Alignment
Next
Instructions
Optimize the image with Focus, Contrast and Brightness. Press the Next button.
Step 1 of 2
Contrast 0.00
Brightness 0.14
Cancel
Alignments
5 - Final Lens Alignment
Previous
Finish
Instructions
Adjust the centre of rotation on screen until it is under the cross in the centre of the screen. Click on Finish to store the new settings or Cancel to return to the original settings.
Step 2 of 2
Final Lens Centering
Contrast 0.00
Brightness 0.14
Cancel

6 - Stigmator Alignment


Alignments
6 - Stigmator Alignment
Start
Instructions
This Alignment removes image shift from the Stigmator by correcting the centering of the beam through the final lens aperture. Press the Start button.
No step



Stigmator Alignment aligns the X and Y accuracy of the Stigmator to reduce image shift when in use.

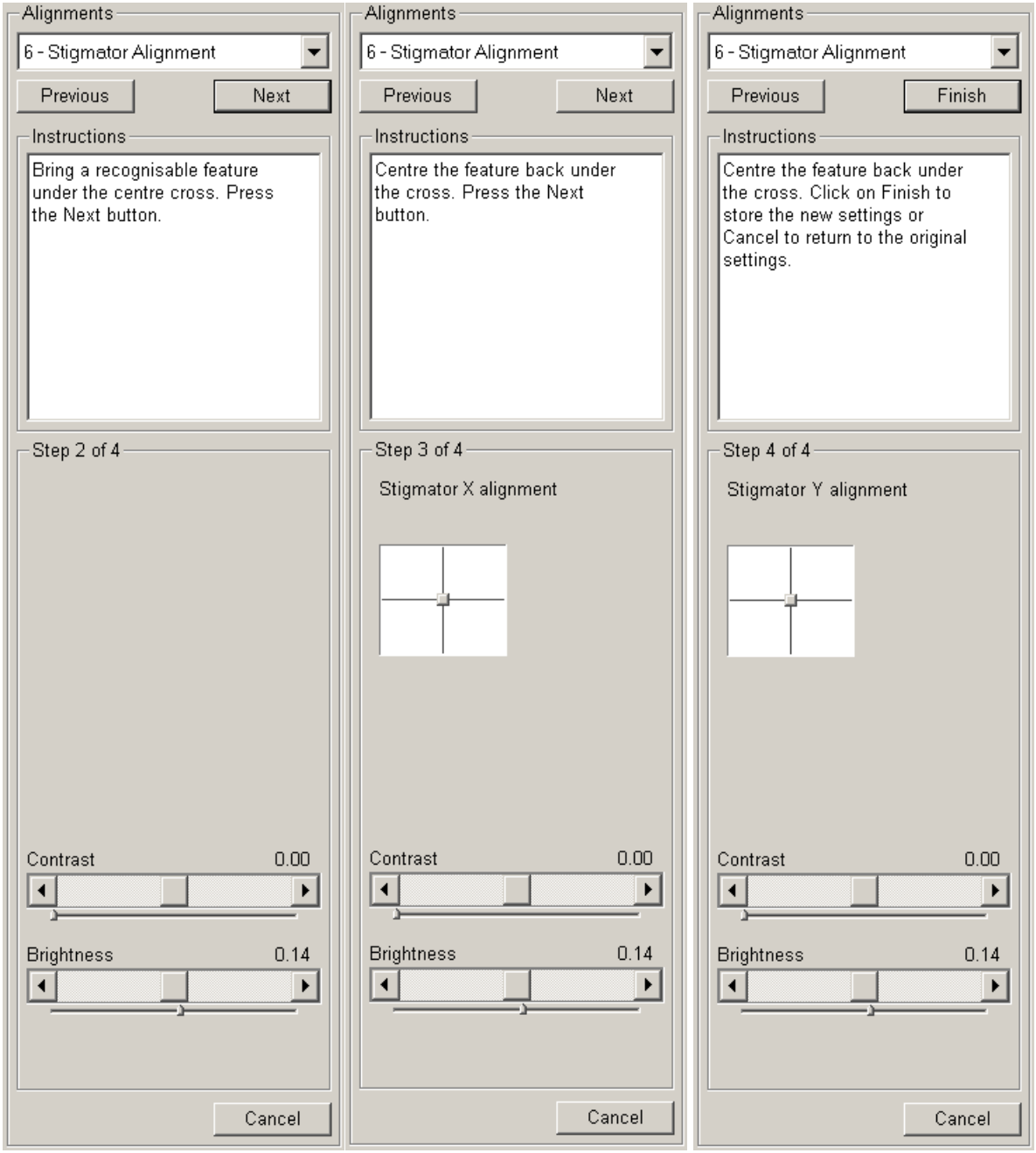
1. The default magnification is 3000x (this is valid only for single screen mode), therefore use a suitable specimen to show regular structure at this magnification. Bring a recognisable image feature under the screen **Centre Cross**.
2. Adjust **Focus** and the **Contrast** and **Brightness** adjusters if necessary.
3. The procedure applies an astigmatism which causes image shift. Using the 2D control labelled **Stigmator X / Y** alignment, remove the image shift. Magnification is increased to approximately 12000x for these 2 steps.

FINAL CHECK

A final check on the quality of the new alignments can be performed by choosing 2000x screen magnification and changing spotsize from 6 to 1 and kVs from 30 kV to 1 kV. If there is very little difference in the position of the objects on the screen during focusing and changing stigmator alignment, the alignment is good.

The Gun and Column User Alignments are now completed.

Stigmator Pages (continued)

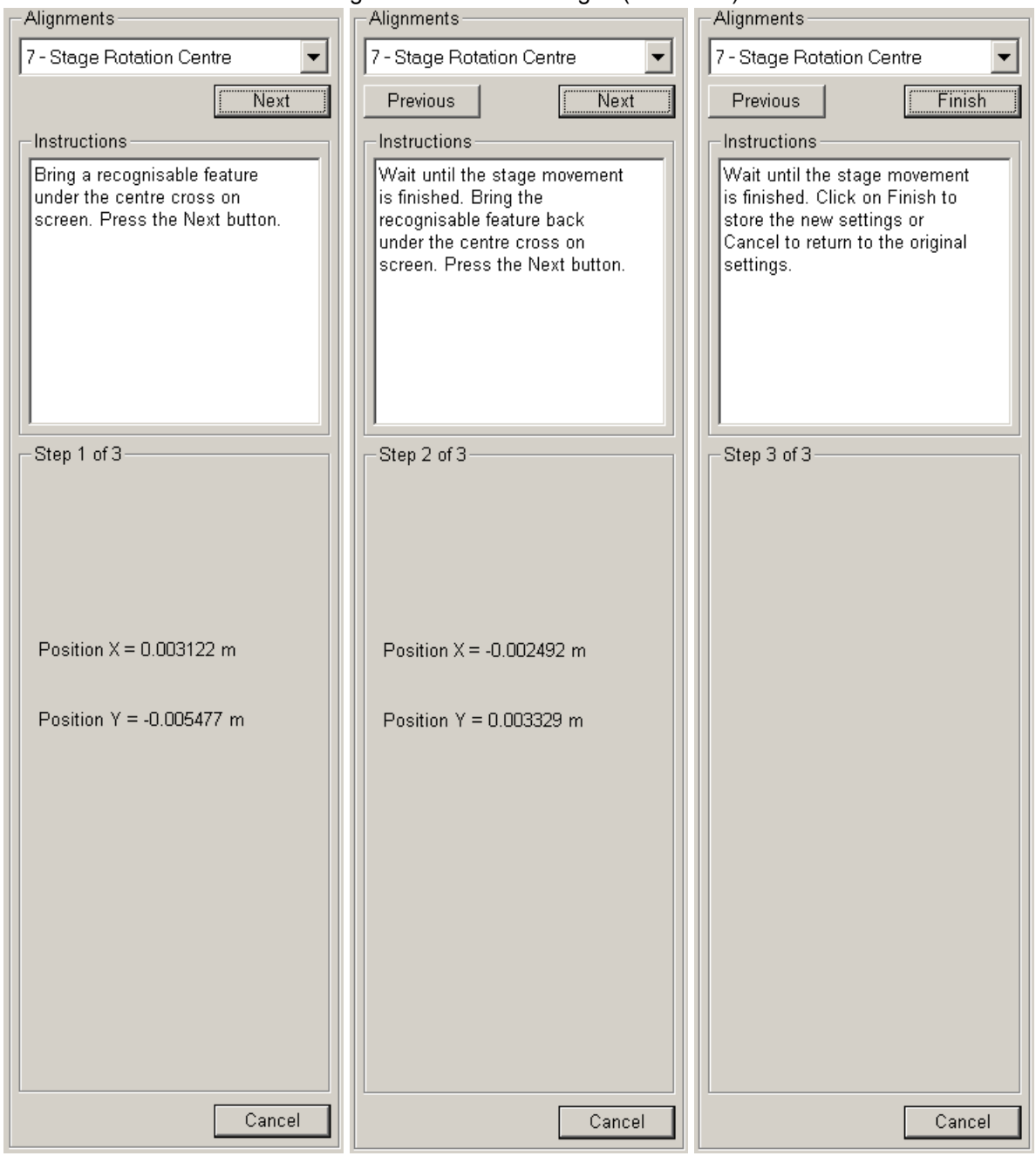


7 - Stage Rotation Centre

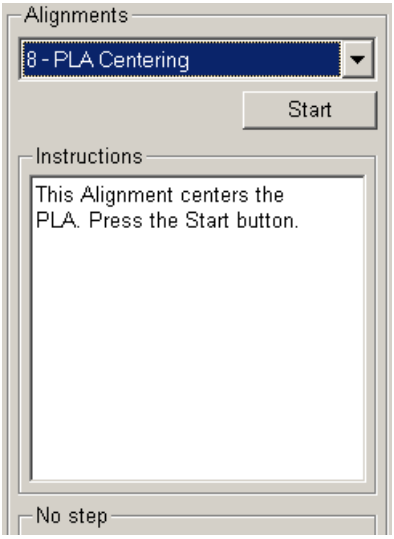
The rotation of the stage has a mechanical center and movement by rotation can be made by changing the value in the text box for R on the Work page. This will move the stage about its mechanical center. In some circumstances this is not desired because rotation about the center of the field of view would be more useful. The following correction is the alignment procedure for the Compucentric Rotation function found in the Stage menu. The offset of X and Y are calculated in this procedure so that the Compucentric Rotation will be correct when computed at any later time.

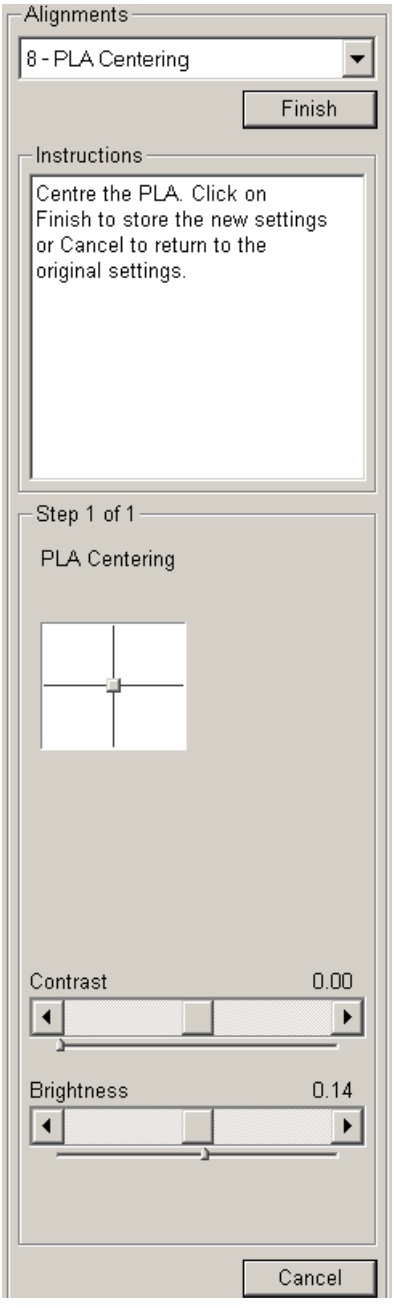
1. The magnification should be from 500x to 2000x, and the sample should have a recognizable feature close to the center of the stub mounted in the center of the stage (do not use IG stub holder or any other axis holder) at this magnification. Bring it under the screen **Centre Cross** by using the mechanical stage movement. A readout of the X and Y coordinates is displayed on the pages. Make sure tilt is zero-adjusted manually if required.
2. The stage automatically rotates the view 180º. Wait until the stage movement is finished. Bring the recognisable feature back under the screen centre cross by using mechanical stage movement. A new readout of the X and Y coordinates is displayed on the pages.
3. Wait until the stage movement is finished.

Stage Rotation Center Pages (continued)


Alignments
7 - Stage Rotation Centre
Next
Instructions
Bring a recognisable feature under the centre cross on screen. Press the Next button.
Step 1 of 3
Position X = 0.003122 m
Position Y = -0.005477 m
Cancel
Alignments
7 - Stage Rotation Centre
Previous
Next
Instructions
Wait until the stage movement is finished. Bring the recognisable feature back under the centre cross on screen. Press the Next button.
Step 2 of 3
Position X = -0.002492 m
Position Y = 0.003329 m
Cancel
Alignments
7 - Stage Rotation Centre
Previous
Finish
Instructions
Wait until the stage movement is finished. Click on Finish to store the new settings or Cancel to return to the original settings.
Step 3 of 3
Cancel

8 - PLA Centering



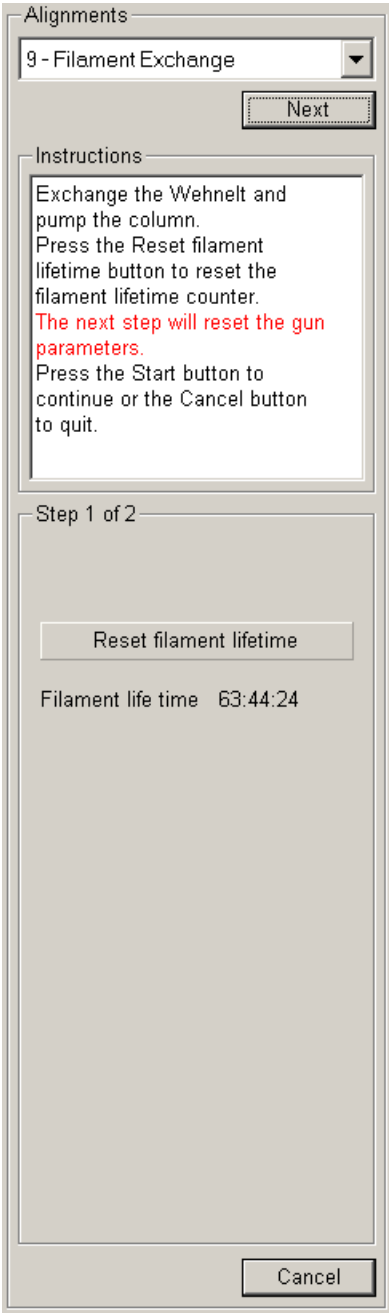


PLA Centering corrects the position of the projected PLA aperture seen on-screen at the lowest magnification when a PLA device is installed. The device holding a PLA can either be a detector or a cone. By using this alignment the area of image can be centered on-screen.

1. Click on the **PLA Centering** 2D control control with the left mouse button, then hold down and move the area of image on-screen to the center of the screen. Release the mouse button.

Note:
PLA Centering should be returned to zero after the PLA is removed by selecting this alignment again and right clicking the 2D adjuster and selecting zero. This will remove the correction, which will no longer be needed since the PLA is not present.

9 - Filament Exchange

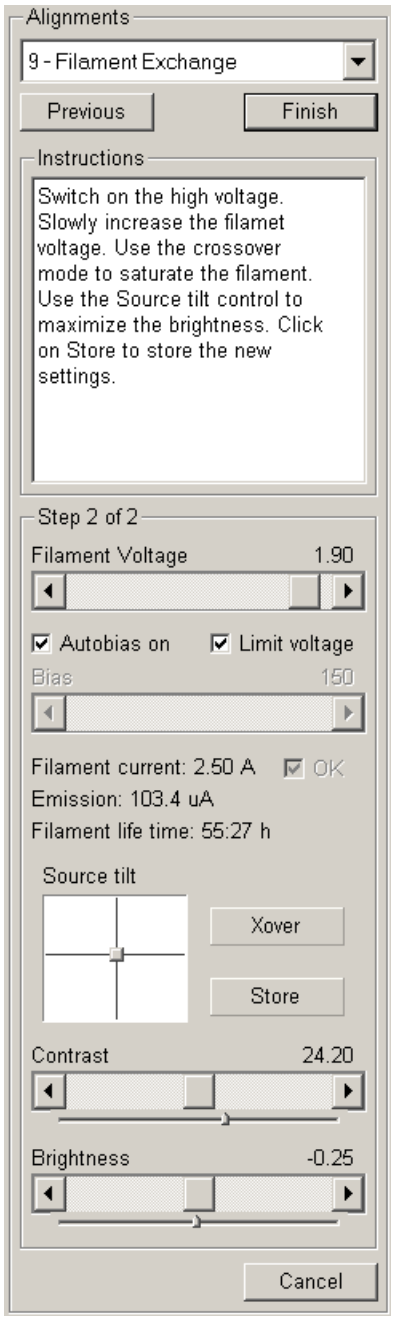

Alignments
9 - Filament Exchange
Next
Instructions
Exchange the Wehnelt and pump the column.
Press the Reset filament lifetime button to reset the filament lifetime counter.
The next step will reset the gun parameters.
Press the Start button to continue or the Cancel button to quit.
Step 1 of 2
Reset filament lifetime
Filament life time 63:44:24
Cancel

When the Wehnelt or Wehnelt filament is replaced, a new saturation value has to be determined for the filament.

1. Insert the Wehnelt and pump to high vacuum. Select the ETD detector in the imaging quad 1.
2. If a new filament is used, press the **Reset filament lifetime** button.
3. Software automatically selects HV 20 kV. Set the **Brightness** adjuster to a gray value and the **Contrast** adjuster so that some noise is visible.
4. Switch on the electron beam by pressing the **Beam On** button in the Beam Control page.
5. Slowly increase the filament heating with the **Filament voltage** adjuster until an emission appears.
6. Carefully saturate the filament. Use the **Xover** mode to check the right saturation.
7. Maximize brightness with **Source tilt** control.

Note:
In this procedure the **Source tilt** 2D control sets the source tilt for all accelerating voltages. The fine correction depending on the accelerating voltage can be performed in the alignment procedure 1 - Source Control.

CONTROL ELEMENTS DESCRIPTION



Step 1

- **Reset Filament Lifetime** button resets the logged filament hours as displayed in the Filament Lifetime text box.

Step 2

See 1 - Source Control Alignment at the beginning of this chapter.

100 - ION: Source Control

ION: Source Control starts Ion source and IGP On / Off. It also shows the actual state of the Ion source and starts the Heat procedure. Only an FEI Supervisor User or a higher level user can access this page.

CONTROL ELEMENTS DESCRIPTION

Step 1 - Ion Source Control

The **On / Off** button starts / stops the Ion source. The behaviour is similar to clicking the Wake Up / Sleep button without influencing to the Electron source and GISes.

I beam emission shows actual Ion Beam current. In the **Maintain** state it should be 2 µA.

The **Offline / Disabled / Idle / Acquire / Maintain / Shutdown** buttons indicate internal Ion source condition. They are accessible only to Service persons.

The **Heat** button starts the heating procedure, which executes automatically at source start according to need. Manual start is advisible when unstable emission and / or unprompted Ion source switch-off take place.

Step 2 - Ion Column Vacuum

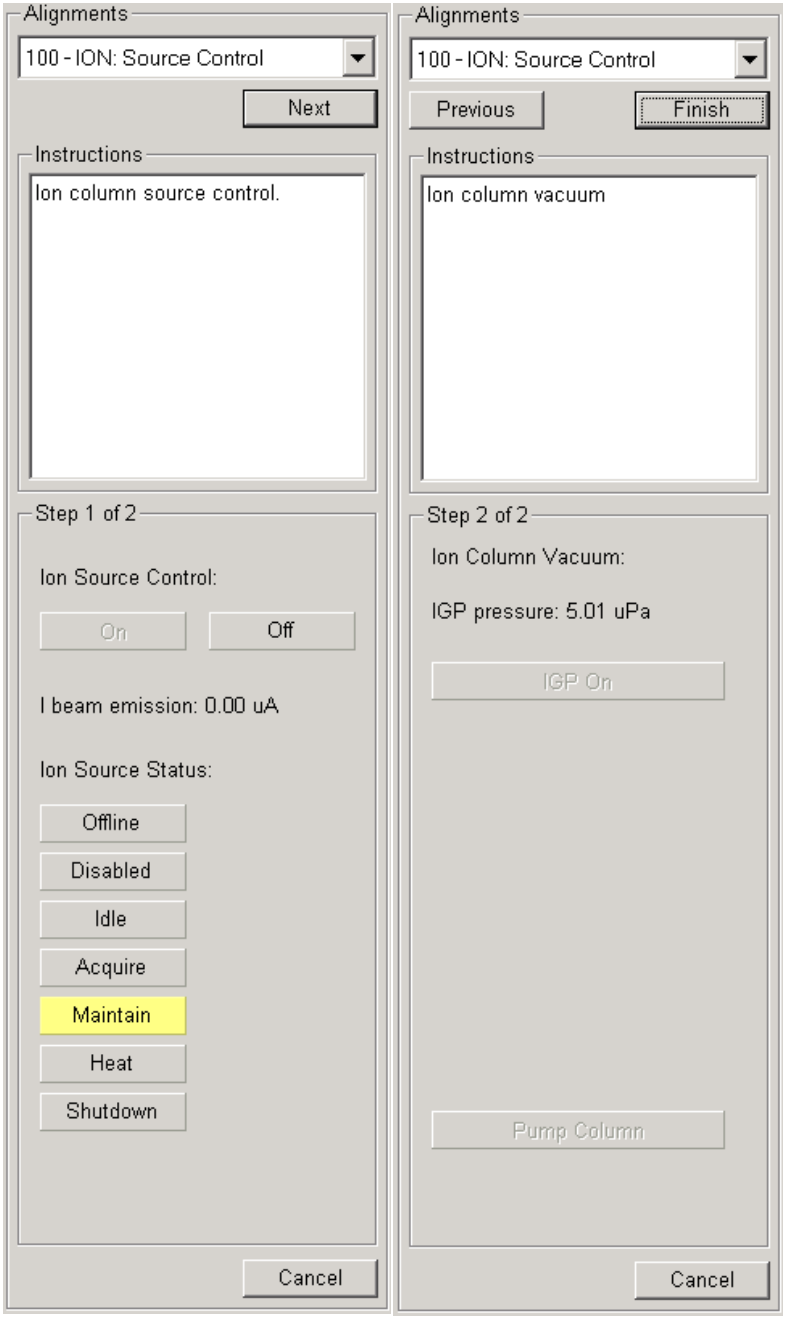
IGP pressure shows Ion source space pressure. Correct functionality requires value <50 µPa.

The **IGP On** button is accessible in case the IGP doesn´t pump– clicking on it starts pumping, which takes at most 10 minutes. If the IGP doesn´t start within this time period, it is necessary to click on the Pump Column button. After successful IGP start an ion source start must follow.

The **Pump Column** button is accessible in case the IGP doesn´t pump and the system is in HiVac mode. It starts the procedure of automatic column pump-down.

Note:
This procedure should be used only when IGP On procedure fails. FEI recommends consulting your authorised service person regarding this procedure.

100 - ION: Source Control (continued)



101 - ION: Aperture Alignment

ION: Aperture Alignment exhaustively adjusts the Ion Column for all voltages and currents.
Only an FEI Supervisor User or a higher level user can access this page.

It is recommended to run 102 - ION: Stigmator Balance procedure (at 30 kV and 100 pA) prior to this one.

STEP 1

The **5 kV / 10 kV / 20 kV / 30 kV** buttons select the voltage at which the adjustment is to be performed (it is usually used for 30 kV, but sometimes for 5 kV also). This adjustment is important for the successful performance of some of the automatic scripts, for instance AutoTEM.

1. Bring a recognisable image feature under the screen **Centre Cross**.
2. Optimize the image with the **Contrast** and **Brightness** adjusters if necessary.
3. Focus the image and correct astigmatism thoroughly at 30 kV, 100 pA.

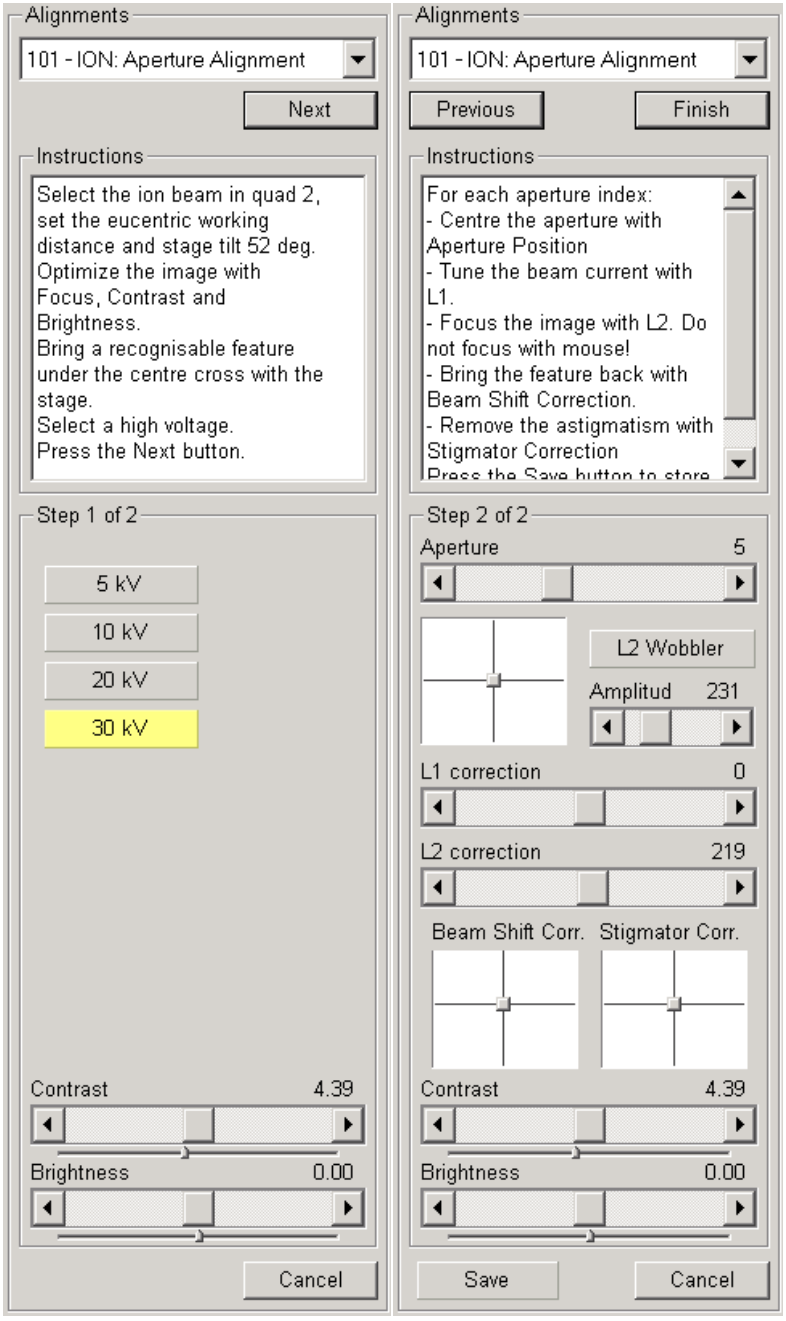
STEP 2

This should be executed for any current which needs adjustment.
Select fast scanning mode.

Note:
when executing this alignment step it is not permitted to sharpen and stigmate with the use of a mouse or an MUI.

1. Choose **Aperture** index.
2. Clicking on the **L2 Wobbler** button switches on the lens system wobbler.
3. By using the **Amplitude** adjuster, choose a suitable wobbler amplitude.
4. By using the **2D control** box, adjust the aperture position so the center of the image doesn´t move.
5. Switch off the **L2 Wobbler**.
6. By using the **L1 Correction,** correct the beam current.
7. By using the **L2 Correction,** focus the image.
8. By using the **Stigmator Corr.,** correct astigmatism.
9. By using the **Beam Shift Corr.,** correct any image shift – bring the feature back to the middle of the screen.
10. Repeat steps from 2–9 until no other correction is needed.
11. Repeat the procedure for another Aperture index.

101 - ION: Aperture Alignment (continued)



102 - ION: Stigmator Balance

ION: Stigmator Balance allows for Octupole fine-tuning and balancing when stigmating for present accelerating voltage and current. It should be executed when the stigmator significantly shifts an image. Only an FEI Supervisor User or a higher level user can access this page.

STEP 1

1. Choose the conditions for which it is necessary to balance the stigmator.
2. Choose fast scanning conditions.

STEP 2

The stigmator wobbler switches on automatically.

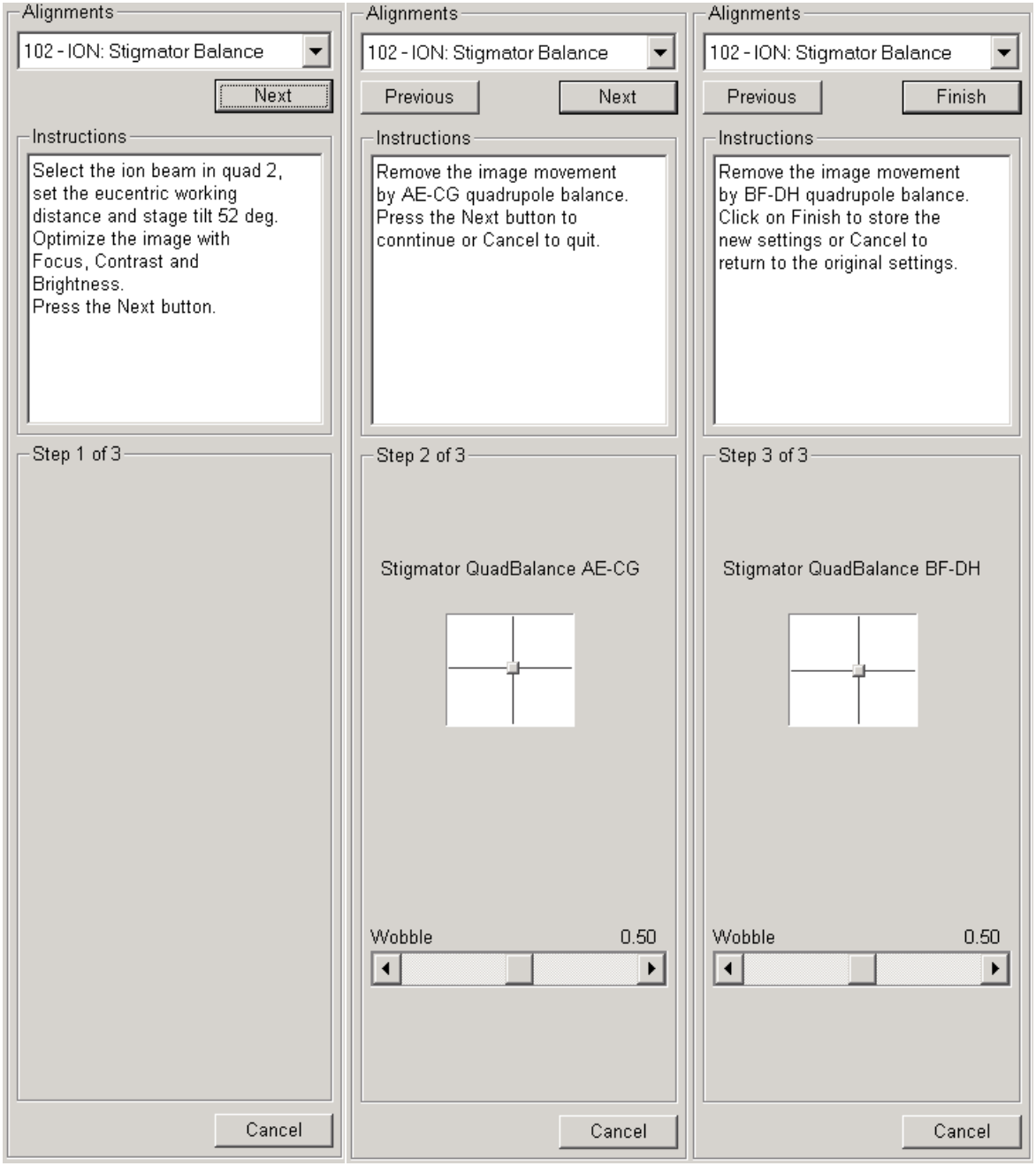
1. By using the **Stigmator QuadBalance AE-CG** 2D control box, balance the first stigmator quadrupole enough to eliminate an image shift.
2. Change the wobbler amplitude and magnification by using the **Wobble** adjuster.

STEP 3

The stigmator wobbler switches on automatically.

1. By using of the **Stigmator QuadBalance BF-DH** 2D control box balance the second stigmator quadrupole enough to eliminate an image shift.
2. Change the wobbler amplitude and magnification by using the **Wobble** adjuster.

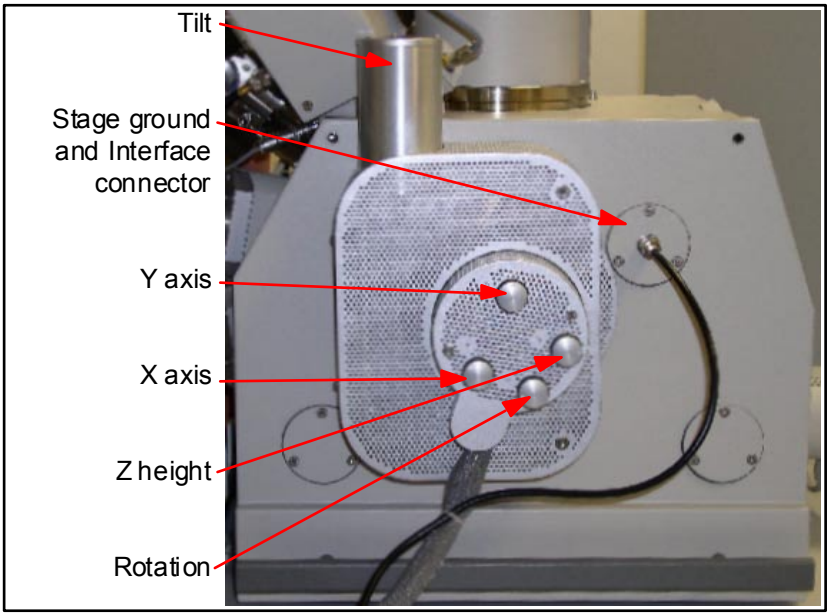
102 - ION: Stigmator Balance (continued)



50 x 50 mm Stage (5-Axis Motor)

The Quanta 3D 200 is delivered with a 50 x 50 mm motorised 5-axis stage. The software control for the stage is an integrated part of the overall control software.

FIGURE 7-1 QUANTA 3D 200 STAGE CONTROLS (5-AXIS MOTOR)



Stage movement

The motorised movements of the stage can be operated under software control for more advanced location mapping. A live image can be repositioned either with stage movement (manual or software) or beam shift.

TABLE 7-1 MOVEMENT TYPES FOR QUANTA 3D 200

Stage Movement	Beam Shift
Get (Mouse) X and Y	**Shift** (Mouse) X and Y
Track (Mouse) X and Y	
Tilt and Z height	
Rotation	Scanrotation
Manual X / Y / Z / R / (Tilt, only on 4 axes)	
Stage Edit Controls / Location	

Software controls for movement include Shift, Get and Track and the Work Page functionality. You can access the Navigation Page by clicking on the appropriate icon above the pages. The stage can be tilted over a 90° range (-15° +75°). The tilt axis always intersects the electron optical axis of the column at the same height (15 mm FWD) for eucentric tilt. When the specimen is positioned at this height, the specimen can be tilted in the eucentric plane.

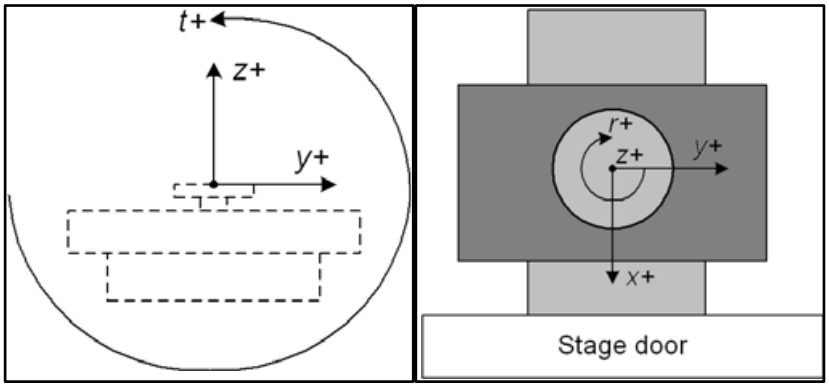
C a u t i o n !

When moving the stage or tilting the specimen, the magnification may need to be reduced so the feature of interest on the screen will not be lost. The maximum sample size (100x50x25 mm) is allowed only for tilt angles in the range -10° to +52°. Exceeding this range may result in damage to the sample or pole piece.

FIGURE 7-2 50 X 50 MM STAGE MOVEMENT

Legend

z = 25 mm (int) + 25 mm (ext)
x = 50 mm
y = 50 mm
t = -15° + 75°
r = 360° (continuous)



QUANTA 3D 200 STANDARD SAMPLE HOLDERS

The sample holders provided with the Quanta 3D 200 consist of a single stub holder and a multiple holder. The single holder has a spring clip fitting and a secure-fitting screw. The multiple holder is a 7-stub holding disc with a spring clip fitting only. Both holders have the same threaded shaft which screws into the stage center and can be securely attached to the stage by means of the conical locking piece.

FIGURE 7-3 STANDARD SAMPLE HOLDERS

The Quanta 3D 200 stage features eucentric tilting and must therefore have a Z position at a set height from the stage rotation head surface to bring the sample surface into eucentric focus.

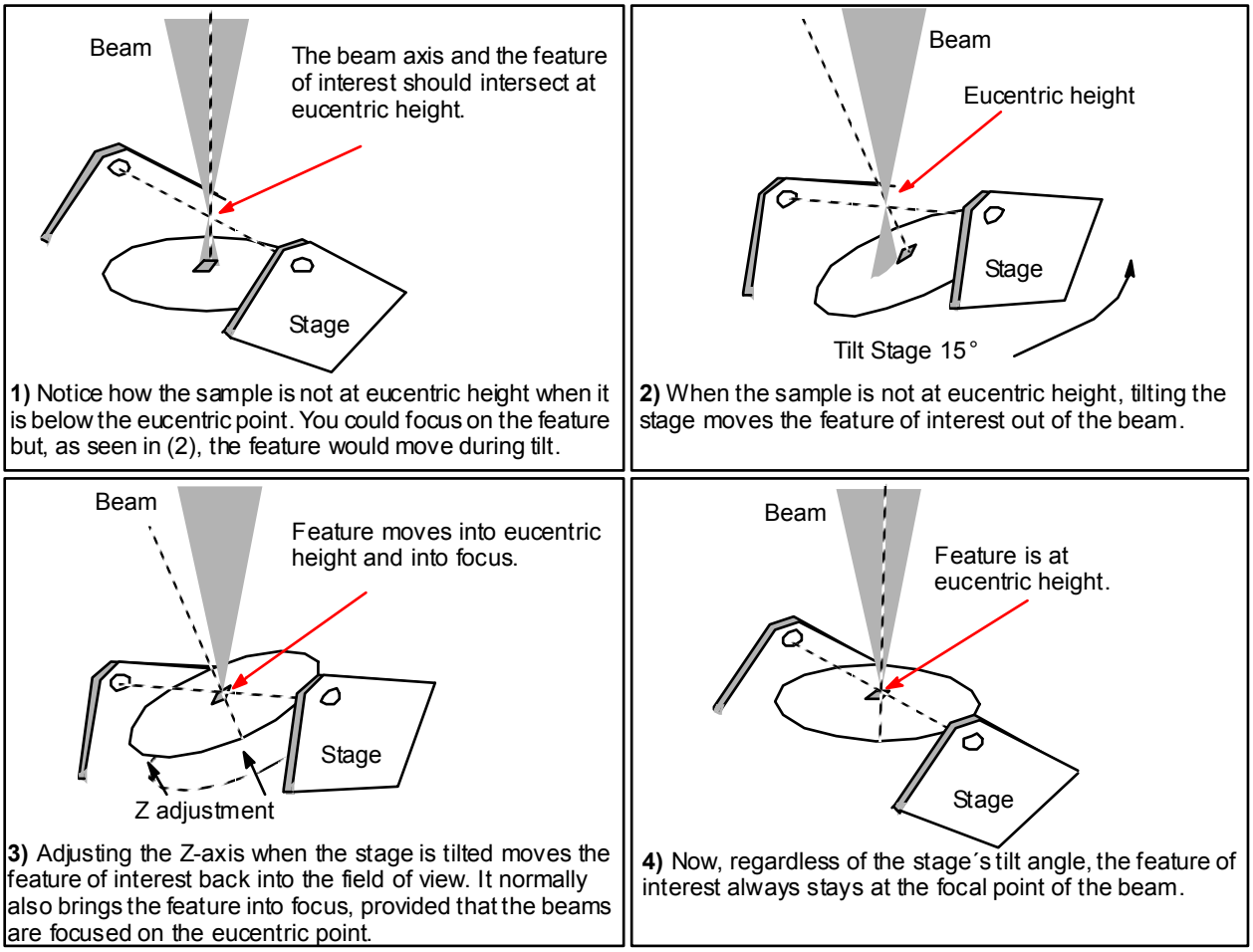
The eucentric holder is screwed into the center of the rotation head of the stage. When the stub is fitted with the specimen, tilting the stage should bring the specimen to the same height as the tilt axis. The specimen should be no greater than 1 to 2 mm thick, or it will be impossible to bring it into eucentric focus.

EUCENTRIC HEIGHT

Establishing the eucentric height is an important part of setting up a sample for observation or modification. The eucentric height should be adjusted after loading any new samples, as the loading procedure clears all height information. When a feature of interest is at eucentric height, you will be able to use the different Quanta 3D workstation components, such as the GIS and EDX, in a safe and optimal way. The eucentric point is the point at which the stage tilt axis and the ion and electron beam axes intersect. At this point, no matter which direction the stage is tilted or rotated, the feature of interest remains focused and almost no image displacement occurs.

Finding the eucentric height on the workstation is a process of positioning the sample so it is at the eucentric point. The following figure is an overview of this process.

FIGURE 7-4 UNDERSTANDING EUCENTRIC HEIGHT



1) Notice how the sample is not at eucentric height when it is below the eucentric point. You could focus on the feature but, as seen in (2), the feature would move during tilt.

2) When the sample is not at eucentric height, tilting the stage moves the feature of interest out of the beam.

3) Adjusting the Z-axis when the stage is tilted moves the feature of interest back into the field of view. It normally also brings the feature into focus, provided that the beams are focused on the eucentric point.

4) Now, regardless of the stage´s tilt angle, the feature of interest always stays at the focal point of the beam.

Finding Eucentric Height

For many samples other than wafers, or for greatest accuracy, use the following manual procedure to obtain eucentric height. Eucentric height requires an E-Beam working distance of exactly 15 mm.

TABLE 7-2 FINDING EUCENTRIC HEIGHT MANUALLY

Step	Action
1.	On the **Stage** menu, select ZERO BEAM SHIFT.
2.	If the small red cross is not already displayed in the center of the screen, press **Shift + F5** to display it.
3.	Obtain an image with the E-Beam and focus. Run the Link Z to WD procedure and go to 15 mm FWD.
4.	Set stage tilt to 0° (Ctrl + E).
5.	At 1000x magnification, find a distinct feature and center it under the red cross by moving the stage.
6.	Watching the feature, change the stage tilt to 15°. Using the Z-control, bring the feature back under the cross.
7.	Change the stage tilt to 52° (Ctrl + I), and bring the same feature back under the cross using the Z-control.
8.	Change the tilt to 0° (Ctrl + E). The feature should not shift significantly. If the shift is > 5 µm, repeat steps 6 to 9.
9.	Tilt from 0 to 52° (Ctrl + I) again to verify that the feature stays in the center of the screen.

Aligning Beams at the Eucentric Height

This procedure assumes that the stage is at eucentric height and that both beams are on.

TABLE 7-3 ALIGNING BOTH BEAMS

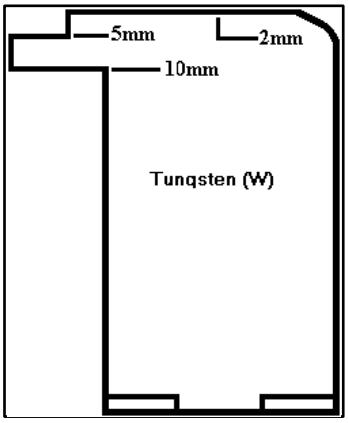
Step	Action
1.	Click on the **Electron Beam** icon in the toolbar.
2.	Tilt the stage to 52°.
3.	While imaging with the E-Beam, and at 1000 X magnification, find a distinct feature and move it under the red cross by moving the stage.
4.	Click on the **Ion Beam** icon in the toolbar.
5.	Using image shift, bring the same feature back under the red cross.
6.	If you cannot align the two images, recheck the eucentric height with the manual procedure.

Note:
After aligning the two beams, avoid using beam shift with the ion and electron beams.

Using Z (height) adjustment

With the standard specimen holder it is possible to change the specimen height inside the chamber, to bring the sample to a eucentric position and to have the flexibility then to change the Z from outside the chamber to another position if required. The internal Z distance is 25 mm of movement, and the external Z distance is also 25 mm. This allows the flexibility to load large or differently sized specimens onto the stage by reducing the internal Z, while still being able to manipulate the difference in height from outside.

FIGURE 7-5 EUCENTRIC ADJUSTER FOR 50 X 50 STAGES

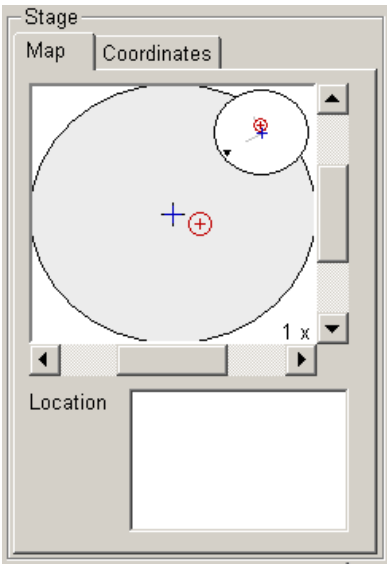


To set the specimen height to the eucentric position, and at the same time prevent any possibility that the specimen should touch the lens pole if the Z is increased, follow this sequence of steps:

1. Load a specimen onto the specimen holder.
2. With the stage still open adjust the external Z (5) to the highest position.
3. Set the Eucentric Height Adjuster on the stage base.
4. Bring the highest specimen or the highest point on the specimen to the 2 mm position on the Height Adjuster by turning the internal screw of the specimen holder. Lock the position with the locking cone.
5. Reduce the Z so that the specimen now coincides with the Eucentric position on the Height Adjuster by use of the external Z control.
6. Close the chamber, and pump down.
7. When the beam is switched on, focus the sample and click on the Z<->FWD button icon on the toolbar. The FWD will be recognised by the system as the value of Z in the Coordinates tab of the Work page.

Now the Z can be changed from the external Z control around the eucentric position and further, but not less than 2 mm from the lens for safety reasons.

Software Stage Functions



The **Navigation Page** has a number of modules including **Stage**, Beam, Smart Scan, Detectors and Status. The uppermost Stage module controls the movements of the stage that locate the position of the specimen by reference to coordinate points. It consists of 2 planes, **Map** and **Coordinates**. These are accessed by the tabs at the top of the module.

MAP TAB

The maximum stage cover is displayed as a large rectangular area with an inscribed circle displaying a center axis cross. All positions to be located and stored will be shown on this large circle and listed in the **Location list** box for selecting.

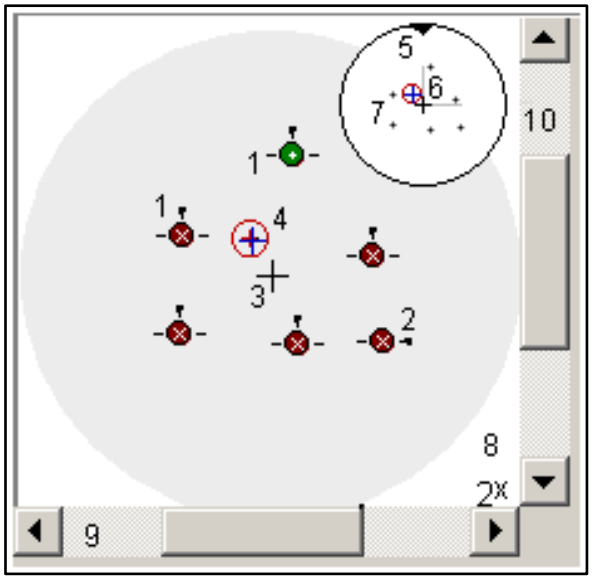
Map Area Elements

The Map area represents the chart of representative locatable positions. They are by default only numbered, although the user may choose to assign names to them. The **Location** box lists all specified locations. The positions and other elements are shown in the Figure 7-6.

Radarview

The small circle in the top right corner of the stage area conveys the rotational position of the stage at any time. To rotate the stage, hold the left mouse button down on the black triangle on the perimeter of the circle and moving it round to the desired position. The stage will rotate accordingly on release of the mouse button. The orientation is seen by the update of the small triangle and the perpendicular lines in the radar view circle.

FIGURE 7-6 MAP AREA ELEMENTS



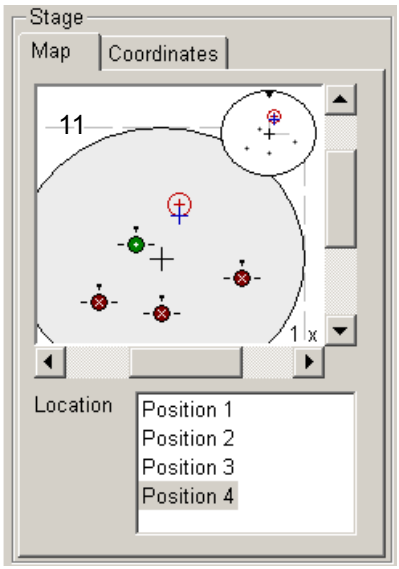


TABLE 7-4 MAP AREA ELEMENT FUNCTIONS

No.	Function
1.	**White × with red background in black circle:** A stored location in the Location list. Without rotation. **White cross on a green background** indicates that a stored position is highlighted in the location list.
2.	**White × with red background in black circle:** A stored location in the Location list with rotation noted by position of the black key.
3.	**Black cross:** Mechanical stage center.
4.	**Blue cross with red circled cross:** The blue cross is a new unstored location and the red circled cross is the current targeted position.
5.	**Black triangle:** The moveable rotation angle positioner.
6.	**Grey perpendicular lines:** Denote rotation position as 5.
7.	**Grey crosses:** Stored positions as on the map.
8.	**1x to 100x:** Magnification factor of the map.
9.	**X adjuster:** to move the mapped area in a X (stage) direction at different decreased magnification factors.
10.	**Y adjuster:** to move the mapped area in a Y (stage) direction at different decreased magnification factors.
11.	**Light grey dashed line:** Physical limit of the stage movement along X and Y axes.

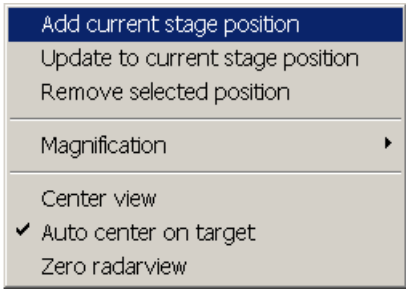
Location

The **Location** list shows the **Current Position** as default. When expanded, it shows the list of positions with a scrollbar. The one selected becomes the current active position. When a position is selected it is highlighted in the list and also on the map as a point with a red circle.

Import / Export

It is possible to load / export STG file with the list of positions (see Chapter 4).

Map dialogue



The **Map dialogue** can be accessed by clicking with the right mouse button in the map area. The different stage sizes will be represented by differently sized shaded circles at default 1x.

Add current stage position

Clicking with the left mouse button anywhere on this circle area will create a blue cross. Then clicking with the right mouse button will provide a dropdown menu which allows the user to add the blue cross position to the **Location** list. By clicking on '**Add current stage position**' this function is carried out. In this way the list can be compiled for particular applications. The blue cross turns black and

receives a black circle around it. The same result can be achieved by means of the **Add** button.

Update to current stage position

Clicking on this stores the (edited) position under the currently selected name.

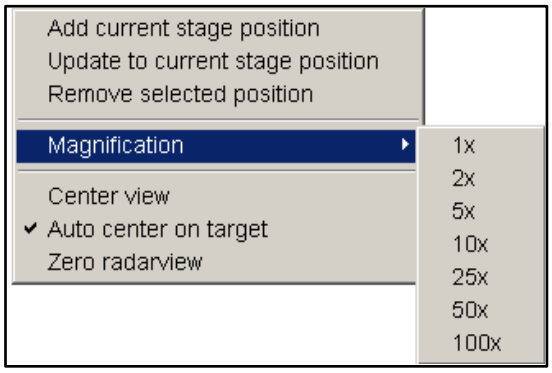
Remove selected position

Clicking on this in the dialogue list will remove the selected position from the map and remove the highlighted label in the location list. The same result can be achieved by means of the **Remove** button.

Magnification (Zoom)

Clicking on the right mouse button while over the Map area, provides the fixed dropdown menu for **Magnification (Zoom)**. Clicking on the item labelled **Magnification** provides a second dropdown menu, which allows the magnification factor of the **Map** area to be selected.

FIGURE 7-7 MAP MAGNIFICATION (ZOOM)



The resulting multiple value is seen in the bottom right-hand corner of the Map area. Scroll bars are present to move over the whole Map area while zoomed in.

Center view

This function brings the selected location to the center of view.

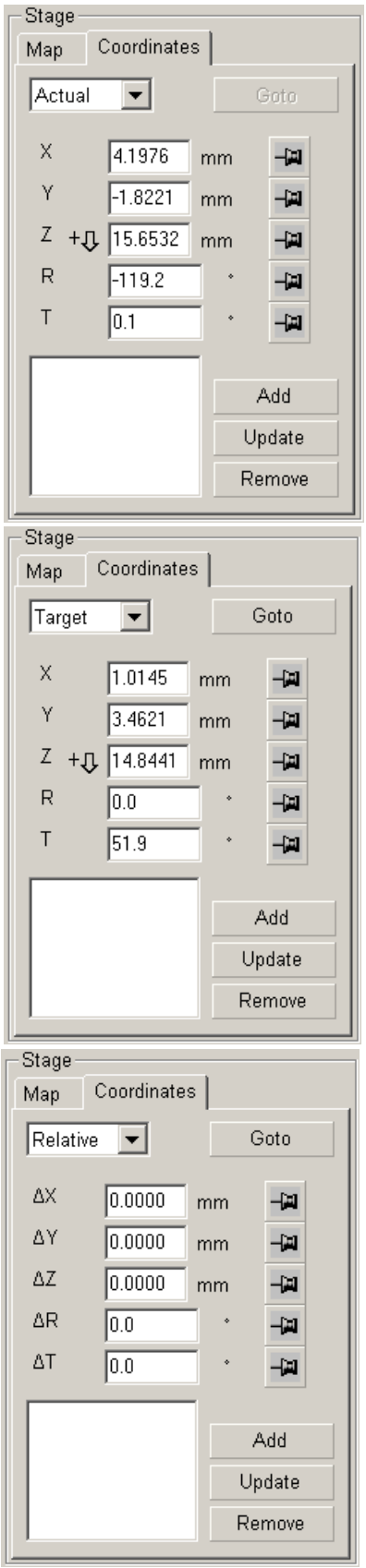
Auto center on target

When using the **Magnification** function the present active location can remain in the center of view if **Auto center on target** is clicked on. This is represented by a tick mark.

Zero radarview

Clicking on **Zero radar view** will bring the radar view circle to zero position (12 o'clock), and rotate the stage mechanically to the home position for rotation movement only.

COORDINATES TAB



A dialogue overlays the **Stage** area displaying a numerical layout for **X, Y, Z, R** and **T** coordinates, **Location List** box for selecting positions and **Action Buttons**. There are three possible modes:

- **Actual Mode** (default) displays actual position in the edit boxes. All buttons are active except **Goto**.
- **Target Mode** activates when clicking on any stored position or when any coordinate value is edited. All buttons are active. Clicking on the **Goto** button drives the stage to the set location.
- **Relative Mode** is used to make repetitive or equal movements in relation to a key point or points. All buttons are active.

Coordinates X, Y, Z, R, T

Five editable text boxes are available for **X, Y, Z, R** and **T**. These are separately editable or can be filled with the values corresponding to a stored position when any of these in the **Location** list is selected.

Units of measure

The units of measure (to the right of the position edit boxes) follow the **Units** setting in the **Preferences** dialogue, unless **User Units** is active (Stage menu), in which case **UU** will be displayed for X and Y.

Location List

In Actual mode (the default mode), coordinates show the values corresponding to the current position and the list of positions with a scrollbar (when needed). The behaviour is as follows:

- Clicking a non-selected item it selects it, which causes the corresponding values to be displayed in the edit boxes. The mode changes to **Target.**
- Clicking a stored position name when it is already selected allows the user to edit the name. Pressing the **Enter** key or clicking a different item confirms the new name. When the user presses the **Escape** key the old name is restored, cancelling the renaming.
- Double-clicking a stored position is the same as clicking it and then pressing the **Goto** button. It immediately moves the stage to the desired position.

Action Buttons

Goto

Clicking this button causes the stage to move to the currently displayed position (in **Target** mode) or to move relative to the current position (in **Relative** mode).

- Pressing the Enter key in any of the position edit boxes acts as a short-cut for the Goto button.
- Double-clicking a position acts as a short-cut for selecting that position and pressing Goto.

Add

Clicking this button creates a new entry in the **Location List**, using the currently displayed position.

- Clicking the Add button in **Relative** mode activates the **Actual** mode and stores the actual position.
- The new entry is called **Position X**, where **X** is 1, 2, 3, etc. If an item with the new **X** already exists (because the user loaded a map list from an STG file), the value is incremented until a unique name is obtained. The user can rename the new entry (see **Location List**).

Update

Clicking this button stores the (edited) position under the currently selected name (overwriting the old position), without asking for confirmation.

Remove

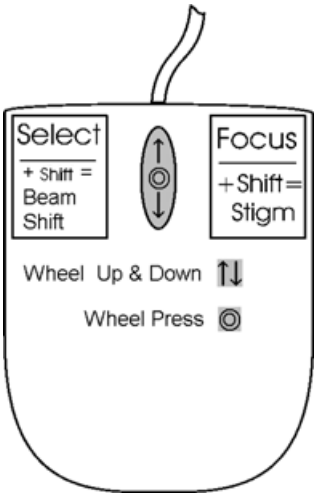
Clicking this button deletes the currently selected item in the **Location List**. The Remove button is enabled when a position is selected in the Location List.

Locks

These are software locks to prevent inadvertent movement of any or all axes during particular applications. By default all axes are unlocked. The edit boxes for axes that are locked are grayed out and cannot be entered or updated. Axes that are locked do not move when the GOTO button is activated. When any or all of the axes are locked the lock icon in **Status** displays a closed lock.

Stage Movements

TRACK

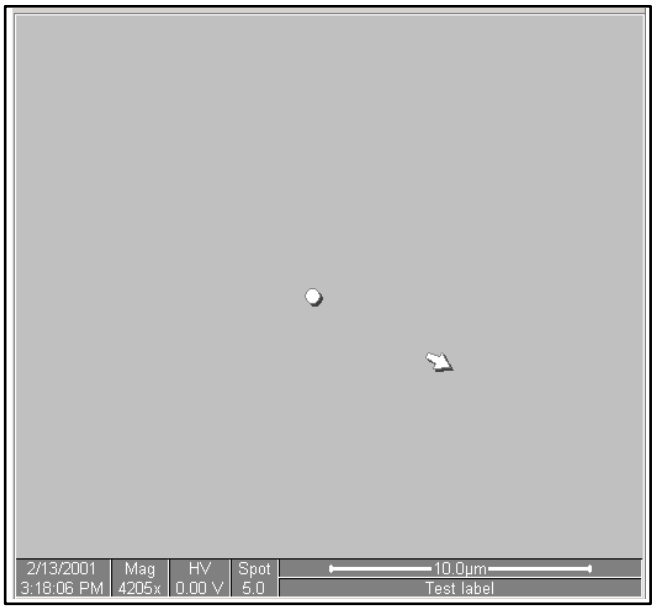


The **Track** function allows continuous directional movement of the stage with variable speed. The speed range is coupled to the magnification and selectable within certain limits.

Select the Track function by pressing on the **Mouse Wheel** while in an active Electron / Ion Beam Quad or on full screen. A Yellow enhanced **Dot** and **Arrow** appear onscreen. The Dot appears where the mouse command cursor was when the wheel was pressed and the Arrow denotes the direction to move. The speed depends on the distance the Arrow is separated from the Dot. The direction can be changed by moving the mouse in a circular motion to obtain the correct path.

The movement axis center will depend on the initial positioning of the command cursor, which can be at any position on the image. Moving away from the Dot with the Arrow increases the stage speed; moving toward the Dot decreases stage speed.The direction of movement is always toward the central Dot along a straight line. You can move the cursor around on the field of view; direction and speed change accordingly. When you are done, release the mouse wheel. The action will stop, and the Dot and Arrow will disappear from the image.

FIGURE 7-8 TRACK FUNCTION

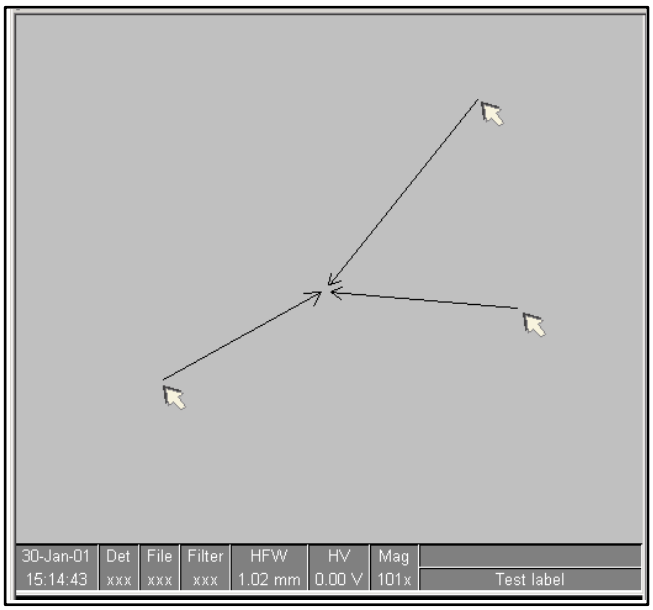


In the Optical Beam Quad the same function activates the Z movement. With the wheel pressed, moving the mouse up will move the Z up and moving the mouse down will move the Z down. This activity can be seen live in the Optical Beam Quad window. The representation of direction is indicated by a centered yellow arrow.

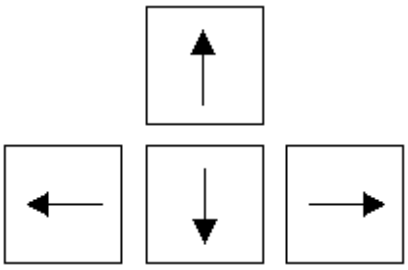
GET

When you select an image object with the cursor and double-click the left mouse button, **Get** brings that detail to the center of the screen. The movement engine automatically calculates, due to magnification, whether to use **Beam Shift** or **Stage movement**. Beam Shift brings the object to the screen center by moving the beam (image field) to an offset position (high magnification). Stage movement will center the object by mechanical movement of the stage and therefore will be limited to a useable range of magnification (lower magnification). When Beam Shift comes to the limit in any direction on a Get command, the Beam Shift will zero and the Stage will be updated for the movement necessary to bring the object to the center. The maximum range for successive Get operations equals the range of the stage movement. At high magnifications, the range is not limited by the maximum beam shift as the stage updates.

FIGURE 7-9 GET FUNCTION

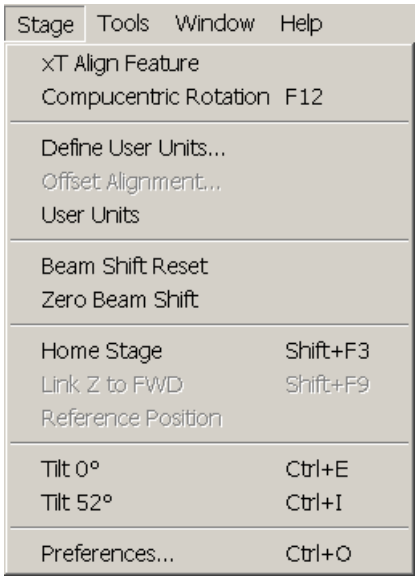


STAGE FRAME SHIFT



The stage can be moved approximately 80% of the field of view in any direction by clicking on the appropriate **Arrow key** on the keyboard. The movement engine automatically calculates, due to magnification, whether to use **Beam Shift** or **Stage movement**. When Beam Shift comes to the limit in any direction, the Beam Shift will zero and the Stage will be updated for the movement necessary to move the frame. The maximum range for successive Frame Shift operations equals the range of the stage movement.

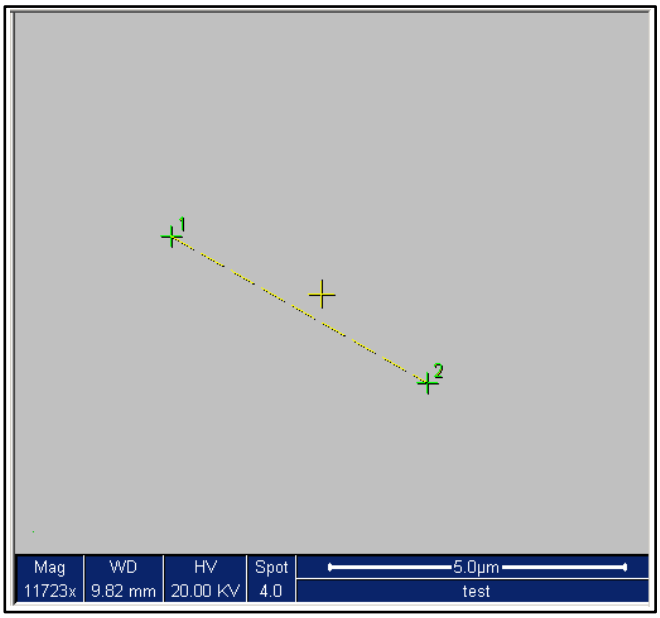
Stage Related Functions



XT ALIGN FEATURE

xT Align Feature is designed specifically for long features, or for when there is need to navigate along a feature that extends off the screen at the magnification required for an observation. Align Feature applies the mapping process across the entire length, bringing the long feature either to the chosen horizontal or vertical axis to make navigation easier. This can be performed at any point within the stage field limits and takes into account the offset for a stage rotation. Point 1 is first located and then point 2. When this occurs, point 2 is not fixed but subtends point 1 with an elastic cord until the left mouse button is released. Point 2 is located at this position. Longer distances result in greater accuracy.

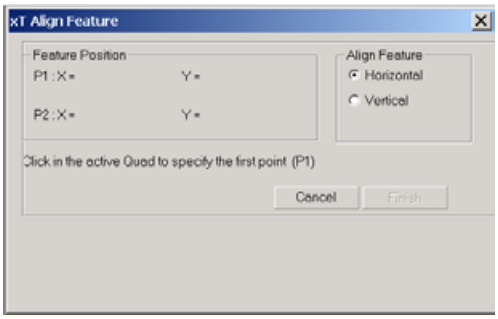
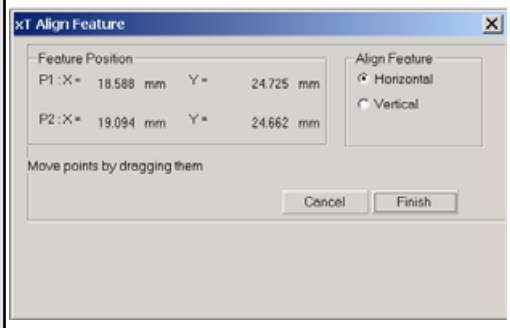
FIGURE 7-10 XT ALIGN FEATURE



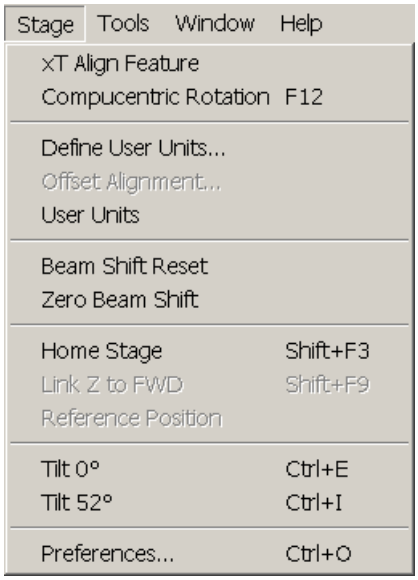
Note:
Align Feature is designed to work best at the eucentric height of 5 mm. The Z to FWD should be corrected to the eucentric height as described in the section ‘Eucentric Height’ on page 7-4.

C a u t i o n !
Because the stage makes movements by software control, care should be taken that there are no obstacles significantly higher on the sample plane set at the eucentric height, as these may interfere with equipment under the lens.

TABLE 7-5 SETTING XT ALIGN FEATURE

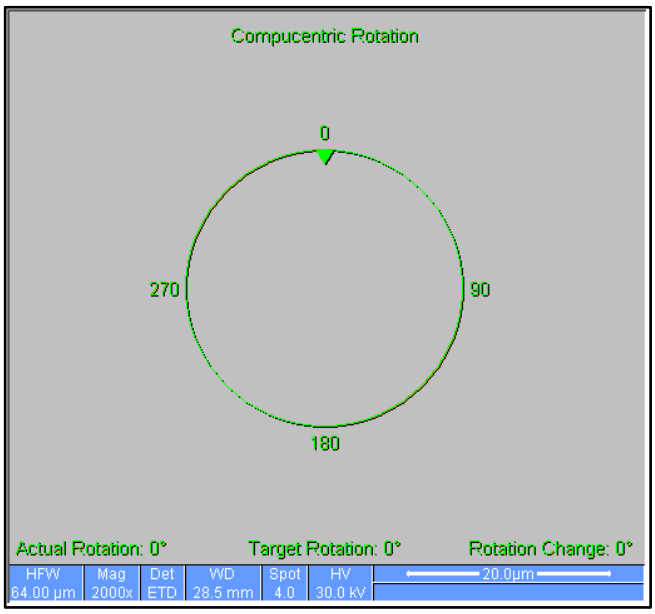
Step	Action
1	Select a long feature on the sample.
2.	Click on **xT Align Feature** from the **Stage** menu. Follow the directions in the dialogue box that appears and choose either Horizontal or Vertical, which relates to the orientation needed on the sample. 
3.	Click with the left mouse button on the first point somewhere along the feature. The coordinates are updated in the dialog. Now drag the line out from the first point to the second point using the mouse. The second coordinates update continuously until released by clicking again. Click on **Finish** to end the selection and for the program to orientate the feature to the selected horizontal or vertical. Click on **Cancel** to cancel the function. 
4.	The stage will move to that location and apply the alignment across the length of the feature.

COMPUCENTRIC ROTATION (F12)



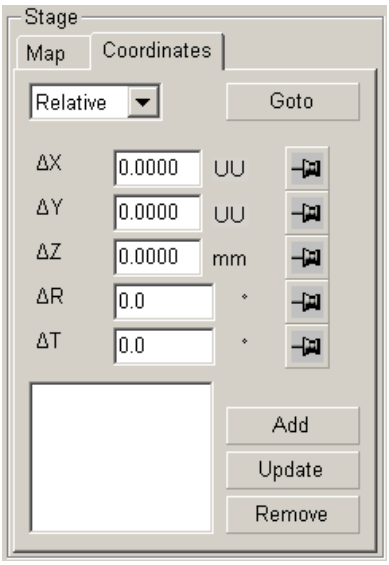
Clicking on **Compucentric Rotation** in the **Stage** menu places a green circle in the active quad. At a point on the perimeter of the green circle is a green triangle which denotes, by its position, the sample´s angle of orientation relative to its original position when placed on the stage. Initially, this is in the 12 o'clock position. While holding the left mouse button down on the green triangle, drag it around the circle to choose a new sample orientation relative to the detection position. On release of the left mouse button the computer software updates the position orientation and offset from the mechanical stage center to deliver the same object center but rotated to the angle selected. This creates a different direction of illumination for the sample while keeping the object of interest in the center of the display area. With the sample at the eucentric height this can be performed at any position on the sample irrespective of the mechanical stage center. Clicking on or near the numbered angles around the perimeter of the circle will cause the stage to drive to that angle and the green triangle will update on screen. Zeroing is accomplished by clicking on the zero on the top of the green circle.

FIGURE 7-11 COMPUCENTRIC ROTATION



The readout positions displayed at the bottom of the quad provide information about the **Actual Rotation** (original position in degrees), the **Target Rotation** (the selected position in degrees) and the **Rotation Change** (the difference in degrees of rotation). Once selected, the control disappears automatically after 10 seconds of no use. The timer is reset each time an adjustment or movement is made.

USER UNITS



To activate User Units as the basis of the stage coordination system, click on **User Units** in the **Stage** menu. A tick mark will appear next to the label. The stage coordinate system will revert to the last defined user unit configuration for 1, 2 or 3 Point Alignment. From this point on the stage can operate in Actual, Target or Relative mode with User Units to perform specific movements.

Define User Units

This associates stage points with user-defined points to set up a mapping between stage and user coordinate system. After that, the computer uses these specimen coordinates rather than stage coordinates for positioning.

For example, a die of an integrated circuit has its own coordinate system. If you choose a 0,0 position, you can drive the stage relative to that position using your own coordinate system. These are expressed in User Unit (UU) coordinates, which may be microns, multiples or fractions of microns, etc. Coordination of the stage can be anchored to either 1, 2 or 3 points, depending on the sample management or application.

Choose points that are not in a straight line, for example at the corners of a die or at the edges of an area or wafer. You can align up to three points, by which the greatest accuracy is achieved.

The following procedure sets up the 1–3 Point alignment for any given sample where repeated structures are checked.

TABLE 7-6 DEFINE USER UNITS PROCEDURE

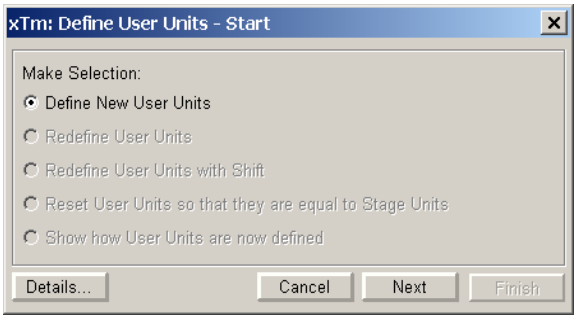
Step	Action
1.	Select a feature on the sample surface and bring it into the field of view at an appropriate magnification so that it relates to other structures.
2.	Click on **Define User Units** in the **Stage** menu. A dialogue appears as follows.  Select from the Start dialogue the **Define New User Units** process by clicking on the radio button. Click on the Next button.

TABLE 7-6 DEFINE USER UNITS PROCEDURE

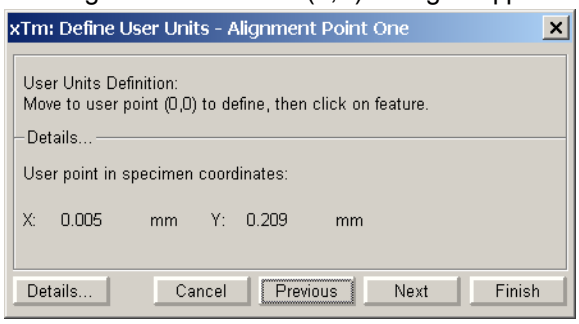
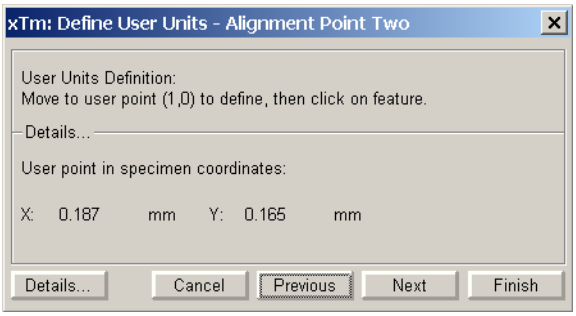
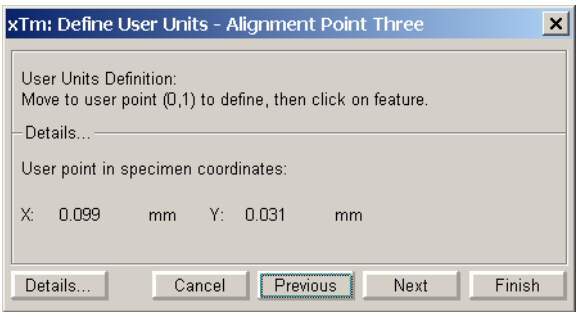
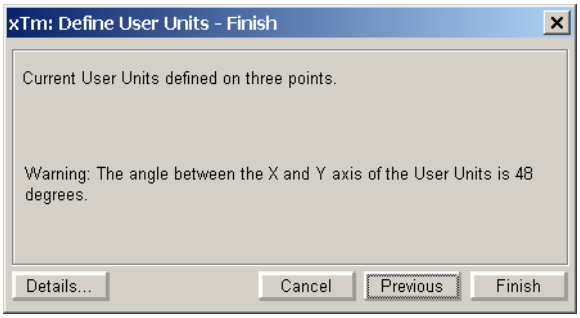
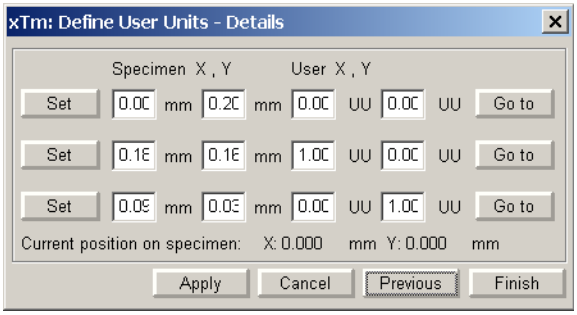
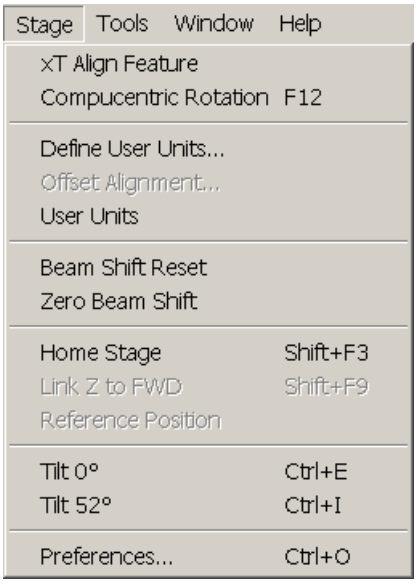
3.	The Alignment Point One (0,0) dialogue appears.  Follow the instruction in the dialogue to move to a point and click on it with the left mouse button. The coordinates of that point (0,0) will appear next to the User X and User Y readout positions in the **Details...** section of the dialogue to choose the next step either: • click on **Previous** to return to the previous dialogue. • click on **Finish** to end the alignment at Point One. • click on **Next** to continue to two points. • click on **Cancel** to exit the procedure.
4.	After clicking on the Next button, the Alignment Point Two (1,0) dialogue appears.  Repeat the procedure, selecting and clicking on a new location point. The User readout positions will show the coordinates for the new Point Two location. Choose the next step from the bottom line of buttons as in Step 3. To continue click on the Next button.
5.	After clicking on the Next button the Alignment Point Three (0,1) dialogue appears.  Repeat the process as in Step 4.

TABLE 7-6 DEFINE USER UNITS PROCEDURE

6.	After clicking on the Next button a confirmation dialogue appears as follows. 
7.	By clicking on the Details button at any stage, either 1, 2 or 3 Points, will cause a display of the resulting coordinates. 



There are a number of choices in the Define User Unit Start dialogue. They are listed here to explain their functionality:

- **Define New User Units** as explained in this chapter.
- **Redefine User Units** for changing or updating User Units.
- **Redefine User Units with Shift** for changing or updating with Beam Shift.
- **Show how User Units are now defined** displays the current details.

While establishing points in the procedure any incorrect point made can be overwritten just by clicking on a new point in the active quad.

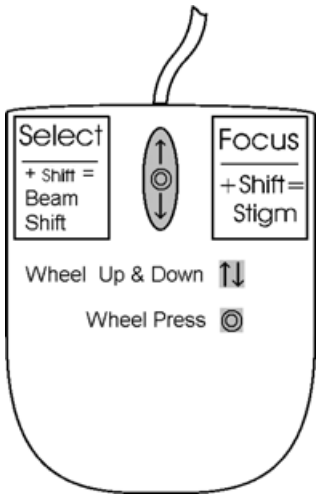
Using 1-, 2- or 3- Point Alignments

The following table shows the different uses of the different alignment types.

TABLE 7-7 ALIGNMENT TYPE DIFFERENCES

Use	1-Point Alignment	2-Point Alignment	3-Point Alignment
Major Use	Aligning to new point directly offset from the existing location	Aligning the stage axes with the specimen X-Y orientation to correct for any skew	Rescaling to nonstandard units on dies or RAM arrays; correcting for any skew
Change in Scale	None	Scales the axes together	X can be scaled differently from Y
Change in Orientation	None	Rotates both axes with a fixed 90° angle between axes	X and Y orientations can be different

BEAM SHIFT



When you select a position on-screen with the cursor and press Shift + the left mouse button, **Beam Shift** controls the cursor (**Hand**) that allows the image area to be moved in any direction. Releasing the mouse button will leave the image area repositioned. The stage does not move during beam shift. When the limit of beam shift has been reached, either **Beam Shift Reset** or **Zero Beam Shift** will need to be clicked on. In this case any stage movement will automatically zero the beam shift and correct it with mechanical movement, so that Beam Shift cannot in reality run to the limit of movement.

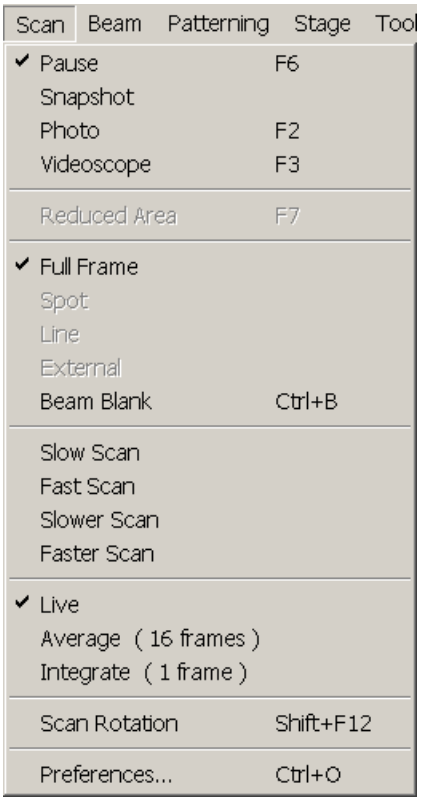
Beam Shift Reset

Use this function to begin the **Beam Shift Reset** procedure to zero beam shift and move the feature to the center of the field of view with the stage.

Zero Beam Shift

When beam shift has reached maximum limits, choose **Zero Beam Shift** to restore X and Y beam shifts to zero values. The computer beeps when maximum limits are reached.

SCAN ROTATION (SHIFT + F12)

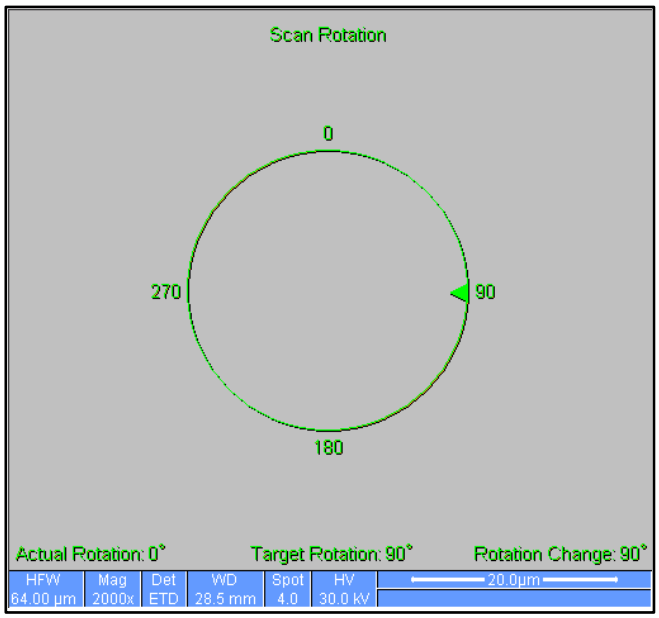


This button is used activate the on-screen tool to rotate the scan and align the image. Because it is solely a scan coil function, it has no effect on the stage movements. Rather, it is used to orient the image relative to mechanical rotation and detector direction.

Using Scan Rotation

Clicking on **Scan Rotation**, in the **Scan** menu, places a large green circle in the active quad with a small circle in the top right corner. At a point on the perimeter of the large green circle is a green triangle which denotes, by its position, the sample´s angle of orientation relative to its original position when placed on the stage. Initially this is at 12 o'clock position. While holding the left mouse button down on the green triangle, drag it around the circle to choose a new scan orientation. The small circle follows suit.The computer software continuously updates the orientation of the scan.This creates a different orientation on the viewing screen but retains the scanning direction on the specimen. The readout positions displayed at the bottom of the quad provide information on the **Actual Rotation** (original position in degrees), the **Target Rotation** (the selected position in degrees) and the **Rotation Change** (the difference in degrees of rotation).

FIGURE 7-12 SCAN ROTATION



Clicking on or near the numbered angles around the perimeter of the circle will cause the beam to drive to that angle and the green triangle will update on-screen on both circles. The smaller circle in the top right of Quad 4 remains on-screen when Scan Rotation is switched off, if the angle is greater than 0°, to inform the user of the orientation.

8 MAINTENANCE

This section describes the procedures necessary for the maintenance of the microscope that can be carried out by the **Supervisor / User**. For the Quanta 3D User maintenance is at a minimum due to Gun and Column design and the long uptime expected from this class of instrumentation. Therefore the more complicated maintenance is normally contained in a service contract to be performed by a qualified Quanta 3D service engineer.

At the User level items such as the following can be maintained:

- 8.1 Cleaning Procedure Overview
- 8.2 Accessing the Column
- 8.3 The Wehnelt and Filament
- 8.4 The Anode Assembly*
- 8.5 The Column Liner and Apertures*
- 8.6 The Standard Insert
- 8.7 Gaseous Detectors
- 8.8 Stage Maintenance
- 8.9 Refilling the Water Bottle
- 8.10 Scroll Pump

Note:
* Although this procedures are explained in this chapter they should be performed by a qualified field service engineer. The exception are those Supervisor/Users, who have had specific FEI instrument maintenance training:

C a u t i o n !

- Parts that operate in vacuum should be handled carefully using clean powder-free gloves. Parts not in use should be stored in suitable containers or packed in aluminium foil.
- the **EDX window** (if present) **is very fragile** and **must be protected from air burst or vacuum turbulence**. It is prudent to remove the detector before major cleaning activities.

Note:
Gas back fill (N_2) should be maintained while the specimen chamber is at ambient pressure. However, to avoid gas waste it is recommended that the chamber should be left open no longer than necessary.

This chapter is organized differently from the rest of the manual to make it easier to find particular procedural items. The sections and subsections are numbered as follows:

Main section: **8.1, 8.2**, etc. Subsection: **8.1.1, 8.1.2 … 8.2.1, 8.2.2**, etc.

8.1 Cleaning Procedures Overview

Frequency of cleaning is, in most cases, determined by necessity due to poor image quality or gross astigmatism level. Recommended cleaning procedures are given below for parts which operate in vacuum and which are subject to possible contamination. These procedures are common to all Quanta instrument configurations.

8.1.1 LIST OF APPLIED CLEANERS

- De-ionized or distilled water
- Ethanol – C_2H_5OH
- Ethanol p/a (Pro Analysis: 99.8% pure) – C_2H_5OH
- Isopropanol
- Neutral pH cleaning fluid (soap solution)
- CIF* or SOFT SCRUB (fine abrasive household cleaner) or 0.05 µm alumina powder

TABLE 8-1 HOUSEHOLD CLEANERS

Country	Name
Austria	CIF
Australia	CIF
Finland	CIF
France	CIF
Germany	CIF
Italy	CIF
Japan	CIF
Netherlands	CIF
Switzerland	CIF
UK	CIF
USA	Soft Scrub

W A R N I N G !
The cleaning solvents ethanol and isopropanol are highly flammable! Do not use open flames and do not smoke while cleaning. Ventilate the room properly.

8.1.2 CLEANING COLUMN PARTS

All column parts are polished before the instrument is delivered. For this reason only occasional light polishing is required to remove contamination that may build up on components in the column and specimen chamber as part of normal operation. Any part that is exposed to the electron beam should be highly polished, and free of contamination and/or scratches that can charge and thus degrade the image.

Parts that can be removed by the general Supervisor/User and polished include the following:

- Wehnelt Cap
- Extracting Electrode
- GSED / LFD components

C a u t i o n !
Gold plated parts should not be polished with abrasives.

8.1.3 MATERIALS AND TECHNIQUE

To polish components, place a lint-free cloth on a flat surface (a glass block is ideal) and apply a small amount of Soft Scrub or CIF and distilled water to the cloth.

Place the part to be cleaned on the polish and rub with a circular motion until all contamination has been removed. For inner surfaces, use a cotton swab or wooden dowel as an applicator. A toothpick can be used for small holes.

Lint-free nylon (not cotton) or latex surgical gloves should be worn while handling parts to avoid contaminating just-cleaned surfaces. Tweezers should be used to hold small parts.

After the part has been polished, remove the Soft Scrub/CIF cleaner by washing in hot water. Inspect the part under a stereo microscope at 20x magnification to ensure that there is no remaining contamination or polish residue. Wash the part in de-ionized or distilled water in a beaker with an ultrasonic cleaner for several minutes.Transfer the part to a clean beaker with alcohol or isopropanol and clean ultrasonically again for several minutes.

Note:
Do not use an ultrasonic bath to clean the GSED or LFD detector.

When the components are dry (a compressed air ‘duster’ can speed drying), reassemble and return to the column. If a part is stained, heat it with hot water and immediately rinse with alcohol and dry using compressed air.

Cleaning Tips

Parts contacted by the electron beam require periodic polishing. It is a recommended practice to clean the Wehnelt Cap every time a filament is replaced. This will ensure maximum performance of the instrument for many years.

Do not use metal polishes such as POL or WENOL to clean parts as these can leave outgassing material. Be aware that threaded surfaces should not be polished as these do not have contact to the beam and are a source of outgassing if polish is trapped. Wash threads with alcohol or isopropanol if absolutely necessary.

After cleaning, inspect all parts for residue and stains using a light microscope.

Down time can be reduced by purchasing spare Wehnelt and detector assemblies and having them cleaned and stored in a safe place, where they can be ready to be installed into the Quanta.

8.2 Accessing the Column

For Tungsten (W) systems the column opens at the emission chamber to allow access to the Wehnelt assembly, anode assembly and liner tube with apertures.

8.2.1 OPENING THE COLUMN

1. Switch off the filament current and the high voltage by clicking off the **HV button** (the colour will change from yellow to grey). The emission will be reduced to zero.
2. Select the **Vent** button in the **Vacuum** module. This switches off the pump system and admits air or nitrogen into the chamber and column after confirmation.
3. When the column and specimen chamber have reached ambient pressure, lift the upper part of the column using the lever until the mechanical stop is reached. While holding it in this position, rotate a quarter turn counter-clockwise. After releasing the lever the upper part will stay in detent position. The Wehnelt assembly is now outside the emission chamber and is grounded by the grounding contact.

Note:
If venting with nitrogen, it is recommended to have a continuous flow of nitrogen while the column is at ambient pressure. This can be done by clicking on **Vent** again when the nitrogen supply has stopped automatically. Once components have been removed for maintenance, the column should be closed again until the components are ready for installing.

8.2.2 CLOSING THE COLUMN

1. Before closing the column, check that the o-ring seal between the two parts is free of dust, hairs or other irregularities that might cause deterioration of the vacuum.
2. Using the lever, rotate the upper part of the column clockwise to position it above the lower part. Carefully lower the upper part in such a way that it fits on top of the O-ring seal located in the lower part of the column.
3. Select the **Pump** button in the **Vacuum** module. The colour of the button will turn from grey to yellow. The automatic vacuum sequence returns the system to the appropriate Vacuum condition.

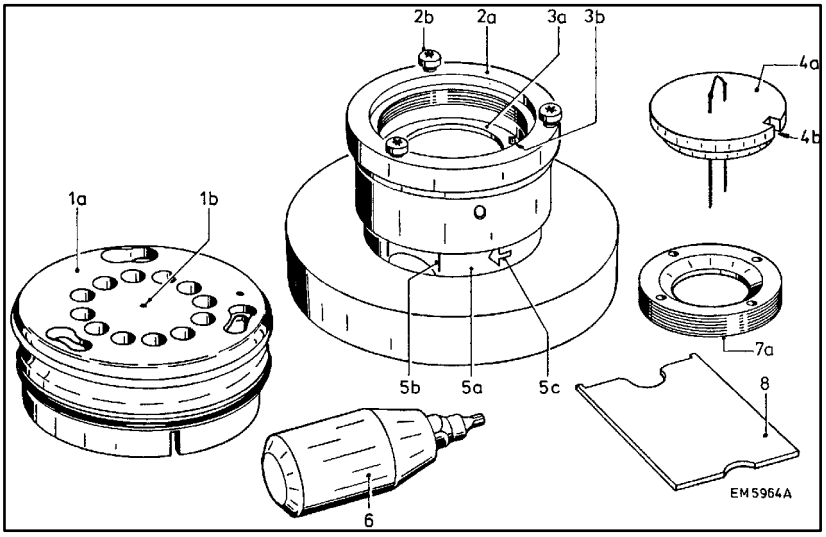
8.3 The Wehnelt and Filament

8.3.1 COMPONENTS

The Wehnelt assembly consists of the following parts:

- **The Wehnelt cap (1a)** with a central hole called the **Wehnelt aperture (1b)**. This cap is fitted onto the upper part of the Wehnelt cylinder (2a) using a bayonet catch mechanism.
- **The upper part (2a)** of the Wehnelt cylinder in which the screws (2b) are located.
- **The middle part (3a)** of the Wehnelt cylinder in which the **Filament base (4a)** is located.
- **The lower part (5a)** of the Wehnelt cylinder with an engraved scale (5b) and arrow (5c).
- **The filament securing ring (7a)**.

FIGURE 8-1 PARTS OF THE WEHNELT CYLINDER



Caution!
All the parts described operate in vacuum and should therefore be handled carefully using clean gloves, and stored, when not being used, in suitable containers or packed in aluminium foil.

8.3.2 REMOVING THE WEHNELT ASSEMBLY

The Wehnelt assembly is held in position inside the holder by a spring ring. To remove it, grasp the Wehnelt assembly at the circular groove using the thumb and fingers of one hand. Apply a force sufficient to overcome the spring pressure in a downward direction, thus detaching the Wehnelt assembly. Lower the upper column back down to keep the emission chamber free of airborne dust.

WARNING!
If the microscope was used for imaging recently, the Wehnelt could be very hot. To handle, use caution and wear gloves made of appropriate heat resistant material, or wait for the Wehnelt to cool.

8.3.3 REMOVING THE FILAMENT

1. Place the Wehnelt assembly in the plastic carrier such that the lower part (5a) of the Wehnelt cylinder can no longer be rotated with respect to the tool. This makes mutual rotation of the two pieces easier when wearing gloves.
2. Rotate the upper part (2a) of the Wehnelt cylinder 3 scale divisions counter-clockwise (in the direction opposed to the arrow (5c)). In this way the filament is retracted from the Wehnelt cap (1a).
3. Using the special screwdriver (6), loosen the three screws (2b) by turning them counter-clockwise over half a turn. This unlocks the bayonet catch so that the Wehnelt cap (1a) can be removed.
4. Unscrew the filament securing ring (7a) using the special tool (8) and remove it from the upper part of the Wehnelt cylinder. The filament (4a) is now free and can be removed and replaced.

8.3.4 CLEANING THE WEHNELT CAP AND FILAMENT SECURING RING

After a period of operation, an evaporated film from the emitter can be observed on the inside of the cap and around the Wehnelt aperture. After 2 or 3 filaments the Filament securing ring also becomes discoloured, this can also be cleaned.

1. Remove the film using cotton wool on the end of a wooden stick, dipped Soft Scrub/CIF and distilled water.
2. Rinse with tap water.
3. Clean in an ultrasonic cleaner for 5 minutes using distilled water in the beaker.
4. Transfer to a new beaker.
5. Clean in an ultrasonic cleaner for 5 minutes using alcohol p/a. or isopropanol.

C a u t i o n !
Do not place parts together in the beakers. Wash separately, as damage can occur to the metal surfaces.

6. First blow dry with a compressed air canister, then dry thoroughly under an infra-red lamp (15 min. to 1 hr.) at a temperature of between 80°C and 100°C. *Do not bake in an oven.*
7. Inspect cleanliness using a light microscope.

Note:
It is not necessary to clean the remainder of the Wehnelt assembly unless severe contamination of the gun chamber has occurred due to another problem.

8.3.5 INSTALLING FILAMENT, WEHNELT CAP

C a u t i o n !
When mounting a filament, great care should be taken in handling it, particularly when adjusting the filament-to-Wehnelt cap distance. If the filament tip is allowed to touch the Wehnelt cap, it can very easily be damaged.

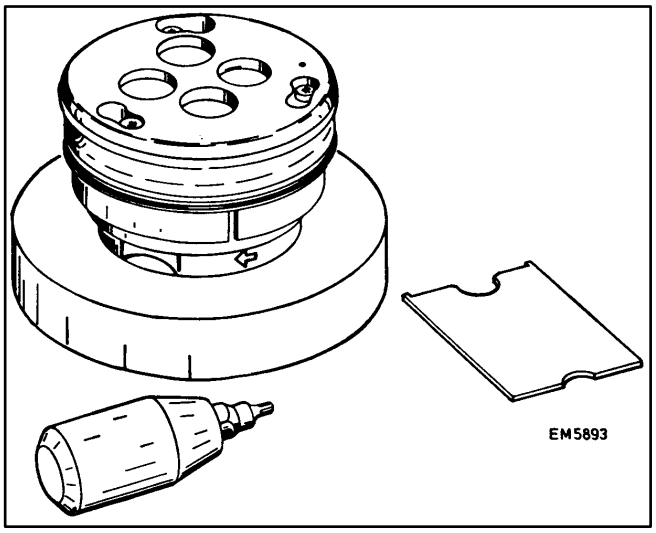
1. Locate the filament unit (4a) in the body of the middle part (3a) of the Wehnelt cylinder, ensuring that the slot on the filament base (4b) engages with the pin (3b).

2. Screw down the filament securing ring (7a) with a spring washer to secure the filament. The ring should be finger-tight only. Too tight a fit might cause the base to crack when heated up during use.
3. Fit the Wehnelt cap (1a) onto the upper part (2a) of the Wehnelt cylinder using the bayonet-catch. This can only be done in the correct orientation.

Note:
Since it might be necessary to clean the Wehnelt aperture, it can be useful to have one spare Wehnelt cap in store. This enables the user to mount a clean Wehnelt cap without losing operating time.

8.3.6 SETTING THE FILAMENT POSITION

FIGURE 8-2 ADJUSTING THE FILAMENT POSITION



1. Using a binocular microscope equipped with an illuminated support platform, centre the filament tip in the Wehnelt aperture (1b) by carefully shifting the Wehnelt cap (1a) over the upper part (2a) of the Wehnelt cylinder.
2. Carefully turn the three screws (2b) finger-tight to secure the Wehnelt cap with respect to the Wehnelt cylinder.
3. Turn the upper part of the Wehnelt cylinder clockwise (in the direction of the arrow) over 1 division with respect to the lower part, to move the filament tip towards the Wehnelt cap. Check that the filament tip does not touch any part of the Wehnelt cap. If necessary repeat steps 1 and 2 with care.
4. Continue this procedure until the tip of the filament is level with the front face of the Wehnelt cap. This can be observed clearly by tilting the Wehnelt assembly and viewing the Wehnelt aperture obliquely.
5. Turn the upper part of the Wehnelt cylinder counter-clockwise (in the direction opposed to the arrow (5c) until the tip of the filament is set to a position between **0.2 and 0.3 mm** below the front face of the Wehnelt cap.
   This can be measured using the scale (5b) on the lower part of the Wehnelt cylinder. Each division represents **0.05 mm**.
6. Recentre the filament tip if necessary (see steps 1 and 2 above).

8.3.7 INSTALLING THE WEHNELT ASSEMBLY

Lift and swing away the gun head assembly, using the handle provided, so that the Wehnelt can be repositioned. Replace the Wehnelt assembly inside the holder attached to the upper part of the column. Ensure that the slots on the assembly engage with the pins inside the holder. A small force, resulting in a 'click', is required to overcome the spring pressure. Close the top of the column.

Pump down the system using the **Pump** button on the **Start-up or Work** page. If the vacuum does not reach the 'Vac OK' message within 10 minutes, the gun o-ring may need to be reseated or replaced.

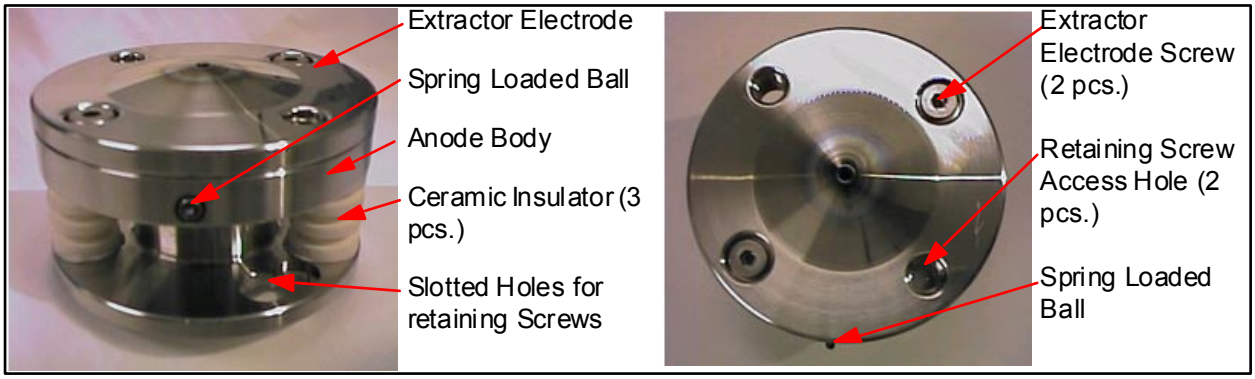
Column alignment may be required after this procedure.

8.4 The Anode Assembly

8.4.1 COMPONENTS

Figure 8-3 shows the basic components of the anode assembly. To access the anode assembly, begin by referring to section 8.2 'Opening and closing the column' in this chapter.

FIGURE 8-3 THE ANODE ASSEMBLY



C a u t i o n !
The parts described operate in vacuum and should therefore be handled carefully, using clean gloves and stored, when not being used, in suitable containers or packed in aluminium foil. ***Under no circumstances should the Anode Assembly be dismantled as it requires factory alignment and sealing.***

8.4.2 REMOVING THE EXTRACTOR ELECTRODE

It is not necessary to remove the entire anode assembly if only the Extractor Electrode needs to be cleaned. It can be removed separately from the complete Anode Assembly. To do this, remove the two Extractor Electrode screws using the anode tool (a 2.5 mm hex wrench can also be used for this), then remove the Extractor Electrode. The anode body will remain in the column.

FIGURE 8-4 ANODE TOOL

8.4.3 CLEANING THE EXTRACTOR ELECTRODE

To clean the extractor electrode, use the same instructions given for the Wehnelt Cap, found in section 8.3.4.

A 500 µm aperture is located in the extractor electrode and is fixed with a c-clip. This aperture should be closely inspected and cleaned or replaced as needed. See the text with Figure 8-8 (Removing/installing Apertures) for instructions on mounting apertures with a c-clip.

8.4.4 REPLACING THE EXTRACTOR ELECTRODE

With dust free gloves replace the EXTRACTOR ELECTRODE onto the ANODE BODY locating the 2 screw holes. Replace the two EXTRACTOR ELECTRODE SCREWS using the ANODE TOOL (a 2.5mm hex wrench can also be used for this). With the Wehnelt in place close the column.

Pump down the system using the **Pump** button on the **Start-up or Work** page. If the vacuum does not reach the 'Vac OK' message within 10 minutes, the gun o-ring may need to be reseated or replaced.

Column alignment is required after this procedure.

8.4.5 REMOVING THE ANODE ASSEMBLY

The following Anode removal and cleaning is a Service Engineer level procedure unless the Supervisor / User has received specific maintenance training. The procedures start with the complete Anode Assembly removal.

1. To remove the entire anode assembly (i.e., to access the column liner), loosen, but do not remove, the two ANODE ASSEMBLY RETAINING SCREWS using the ANODE TOOL shown in Figure 8-4 (a 2.5 mm hex wrench can also be used). The screws are at the base of the assembly and are accessible through the two RETAINING SCREW ACCESS HOLES in the top of the assembly.
2. Grasp the anode assembly with a gloved hand, gently push, then twist counter clockwise until it stops and pull up.

Anode Body

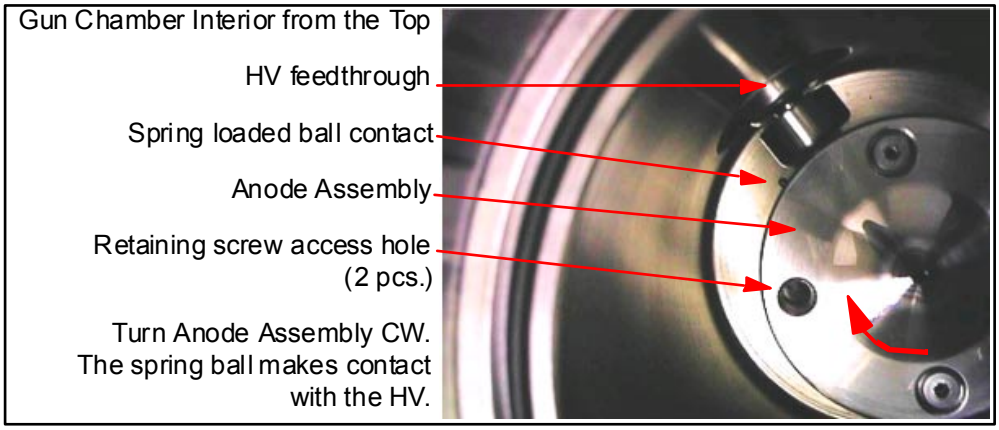
The anode body does not require regular cleaning. If cleaning the anode body becomes necessary, clean only those areas near the beam path that require cleaning. Use a minimal amount of cleaner, and a minimal amount of liquid, and try not to wet the three porous ceramic insulators while rinsing. If the ceramic insulators are cleaned, bake the anode assembly in a clean oven for five hours (or overnight) at 60°C (140°F).

8.4.6 INSTALLING THE ANODE ASSEMBLY

Ensure that the liner tube along with its apertures and upper o-ring have been correctly installed.

Figure 8-5 shows the inside of the column, looking down in from the top. Refer to this picture for the following instructions.

FIGURE 8-5 INSTALLING THE ANODE ASSEMBLY


Gun Chamber Interior from the Top
HV feedthrough
Spring loaded ball contact
Anode Assembly
Retaining screw access hole (2 pcs.)
Turn Anode Assembly CW. The spring ball makes contact with the HV.

1. With a gloved hand, place the ANODE ASSEMBLY into the gun chamber so the SPRING LOADED BALL CONTACT is near the HT FEEDTHROUGH and align the slotted holes with the retaining screws on the bottom of the chamber.
2. Push in and twist the anode assembly clockwise to lock it into place. The SPRING LOADED BALL CONTACT should rotate into position against the HT FEEDTHROUGH. Use the anode tool to tighten the retaining screws. With a Wehnelt installed close the column.
3. Pump down the system using the **Pump** button on the **Start-up or Work** page. If the vacuum does not reach the 'Vac OK' message within 10 minutes, the gun o-ring may need to be reseated or replaced.

Column alignment will be required after this procedure.

8.5 The Column Liner and Apertures

8.5.1 COMPONENTS

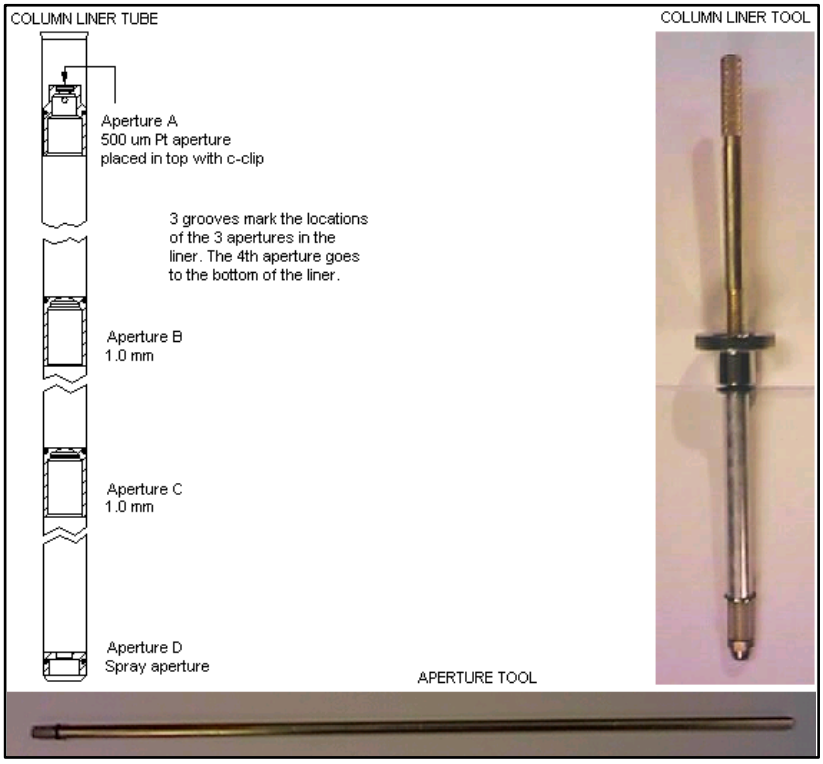
The following Column Liner removal and cleaning is a Service Engineer level procedure unless the Supervisor / User has received specific maintenance training.

The Column liner tube contains four apertures:

- **A** - 500 µm platinum aperture mounted in a holder at the top
- **B and C** - two 1.0 mm spray apertures in the middle
- **D** - open-type spray aperture at the base

The aperture tool is used to install the apertures at the correct positions inside the tube. The column liner tool is used to remove and install the column liner. Instructions are given in the following sections.

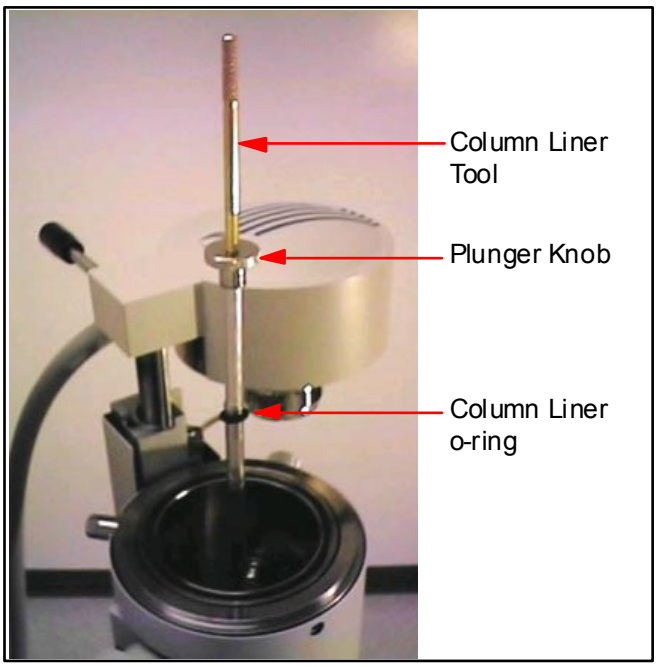
FIGURE 8-6 LINER TUBE, APERTURES, TOOLS



8.5.2 REMOVING THE LINER TUBE

1. Vent the system and remove the anode assembly. See Section 8.5.2
2. Insert the COLUMN LINER TOOL into the end of the liner tube and tighten the PLUNGER KNOB.
3. Raise the tube carefully until it is clear of the column. The upper COLUMN LINER O-RING should come out with the tube. If it doesn't, remove the o-ring from the gun chamber.
4. Loosen the plunger knob to remove the column liner tool from the tube.

FIGURE 8-7 REMOVING THE COLUMN LINER TUBE



Removing Apertures from the Liner

Mounting positions are critical and the following instructions should be carefully followed. The apertures are removed and installed using the APERTURE TOOL.

Extract the apertures by inserting the APERTURE TOOL into the lower (tapered) end of the liner tube and pushing it forward as far as it will go. The apertures should slide out easily.

Removing Aperture (A) from Holder

Place the aperture holder with its open slotted end on a flat surface and grasp it firmly with one hand.

Insert one blade of a pair of needle-pointed tweezers under the c-clip, making use of the slots in the holder, and then carefully pull out the c-clip.

Remove the aperture either by lifting out with the tweezers, or by inverting the holder over filter paper, a Petri dish, or other suitable surface.

8.5.3 PLATINUM APERTURES CLEANING

Method 1:

Heat the aperture (held in special tweezers with platinum points) in a clean gas flame until red-hot (for 4–20 seconds). Take care that the aperture does not melt or become stuck to the tweezers.

Method 2:

Connect a V-shaped molybdenum foil boat (about 2 cm long) across the low voltage / high current contacts of a Vacuum Evaporator unit. Use a vacuum of $1x10^{-5}$ Torr ($1.3x10^{-3}$ Pa) and heat until white hot to flash decontaminate. Do not allow the Vacuum Evaporator to contact the atmosphere until the foil boat is cool. When the aperture has

cooled down, place it on the foil, vacate, and reheat the foil to red heat on the aperture (for 4–20 seconds). Take care that the aperture does not melt or become stuck to the foil. Again, do not allow the Vacuum Evaporator to contact the atmosphere until the foil boat and aperture is cool.

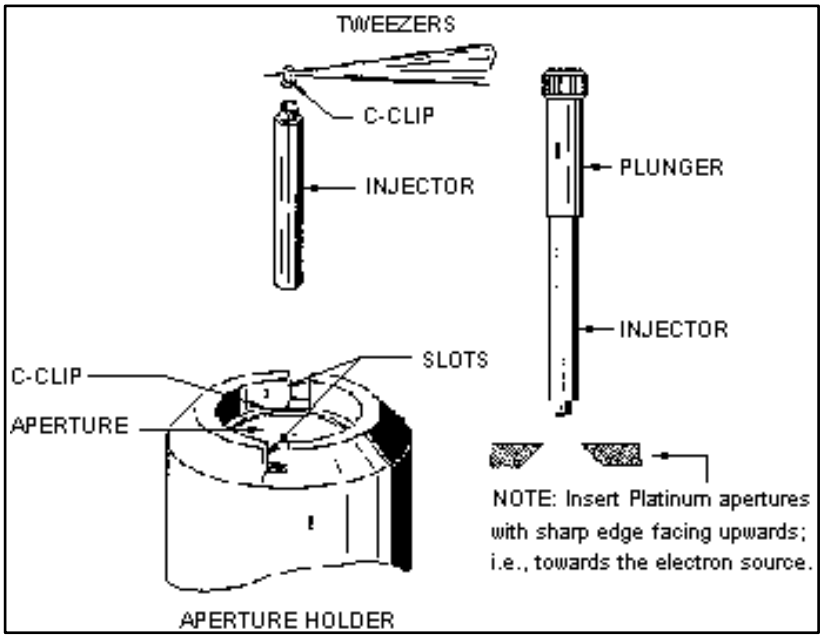
C a u t i o n !

Do not attempt to clean apertures just by washing in solvent, as this can have an adverse affect just by shifting contamination back onto the aperture.

Polishing scratches the soft material and makes the aperture unusable for high resolution. All apertures must be cleaned and must not have scratches at the center hole. The top aperture should not have any scratches or defects.

8.5.4 INSTALLING APERTURE (A) IN HOLDER

FIGURE 8-8 REMOVING / INSTALLING APERTURE A



1. Place the aperture holder with its open slotted end on a flat surface and grasp it firmly with one hand.
2. Using tweezers, carefully insert the aperture, sharp edge uppermost, into the seating on the upper end of the holder.
3. Again using the tweezers, insert the c-clip into the tube of the injector provided.
4. Depress the plunger slightly until the plane of the c-clip within the tube is approximately at a right angle to the axis of the tube. Release the plunger.
5. Place the injector vertically into the aperture holder, so that the tube rests on top of the aperture.
6. Depress the plunger to push out the c-clip. The pressure must be continued while retracting the body of the injector so that the c-clip remains in place in the holder seating.
7. Remove the injector and check that the aperture is properly clamped by the c-clip. This can be done either by inverting the holder over a Petri dish and tapping lightly; or by observing the position of the c-clip with a magnifying glass.

Note:
Always check the mounted aperture under a binocular microscope or with a magnifying glass to make sure that no hairs or other contaminants are on the aperture or between the aperture and the c-clip.
Be careful not to lose a small parts, especially the c-clip!

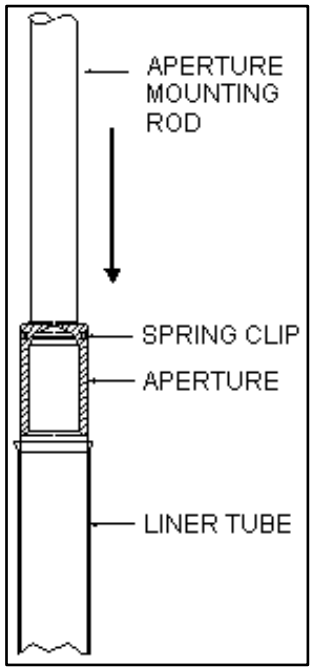
The following additional instructions on inserting the apertures should also be noted:

- The platinum apertures must be installed so that the polished side faces up, or towards the electron beam source.
- Installing the c-clip into the insert is done using both the aperture tool and the injector / plunger tool. Use tweezers to insert the c-clip into the injector tool, then use the injector tool to install the c-clip into the aperture insert.
- To put on the o-ring, push it onto and over the top of the insert, making sure not to roll or deform it in any way.

8.5.5 APERTURE POSITIONING IN THE LINER

1. Insert spray aperture D into the top of the liner tube and push it all the way to the bottom with the aperture tool. The open end of the aperture faces down.
2. Insert aperture C (1 mm spray aperture) into the top of the liner tube. The top of the column liner is flared outward and the 1mm hole of the aperture should face up.
3. The aperture tool has a knurled end and three grooves cut into it. Hold the aperture tool by the knurled end (top) and push the aperture into the liner tube until the groove nearest the knurl (top) is exactly level with the top of the liner.
4. Repeat step 2 for aperture B (1mm spray aperture) but use the next groove down on the tool to place the aperture. (Aperture B and C are identical and can be interchanged.)
5. Repeat step 2 for aperture A. The platinum aperture should face up and the third groove down should be used to place this aperture.

FIGURE 8-9 APERTURE MOUNTING



Note:
Take care not to drop or jar the tube during or after this procedure, as this may move the apertures from their correct positions. The apertures are held in place by spring clips. If an aperture feels loose going into the liner or slips from its position, then the spring clip can be opened up slightly to increase tension against the liner tube inside wall.

8.5.6 CLEANING THE LINER TUBE

1. Clean the inside of the tube with a pipe cleaner or a wooden stick with cotton wool wrapped around it, using Soft Scrub/CIF cleaner.
2. Rinse in tap water.
3. Clean in an ultrasonic cleaner for 5 minutes using distilled water in the beaker. The liner is long, so it may be necessary to reverse it in the beaker and give it a further five minutes cleaning time.
4. Rinse with de-ionized or distilled water.
5. Transfer to a new beaker.
6. Clean in an ultrasonic cleaner for 5 minutes using alcohol p/a. or isopropanol. The liner is long, so it may be necessary to reverse it in the beaker and give it a further five minutes cleaning time.
7. Rinse with alcohol p/a. or isopropanol.

C a u t i o n !
Do not place parts together in the beakers. Wash separately as damage can occur to the metal surfaces.

8. First blow dry with a compressed air canister, then dry thoroughly under an infra-red lamp (15 min. to 1 hr.) at a temperature of between 80°C and 100°C. *Do not bake in an oven.*

8.5.7 INSTALLING THE LINER TUBE

1. Ensure that the apertures are correctly mounted in the liner and that the column liner upper o-ring is on the liner.
2. With a gloved hand, carefully push the liner down into the column until it seats on the bottom o-ring. The column liner tool can be used to re-insert the liner tube, also.
3. Refer to section 8.4.6 ‘Installing the Anode Assembly’ to complete the column installation procedure.
4. With a Wehnelt installed close the column.
5. Pump down the system using the **Pump** button on the **Start-up or Work** page. If the vacuum does not reach the ‘Vac OK’ message within 10 minutes, the gun o-ring may need to be reseated or replaced.

Column alignment will need to be performed after this procedure.

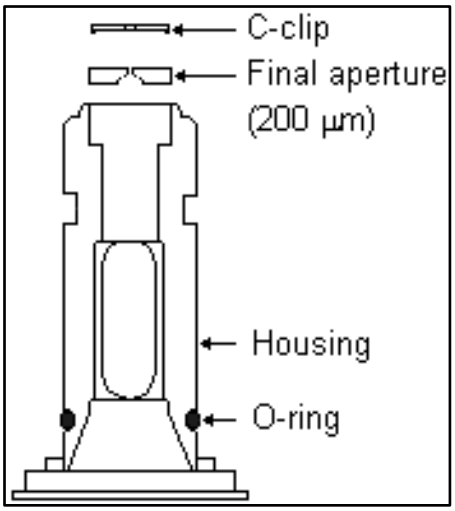
8.6 The Standard Insert

The following tools and procedures are used to install and remove the standard insert from the lens pole and to assemble Pressure Limiting Apertures and the Insert body.

8.6.1 REMOVING AND DISASSEMBLING

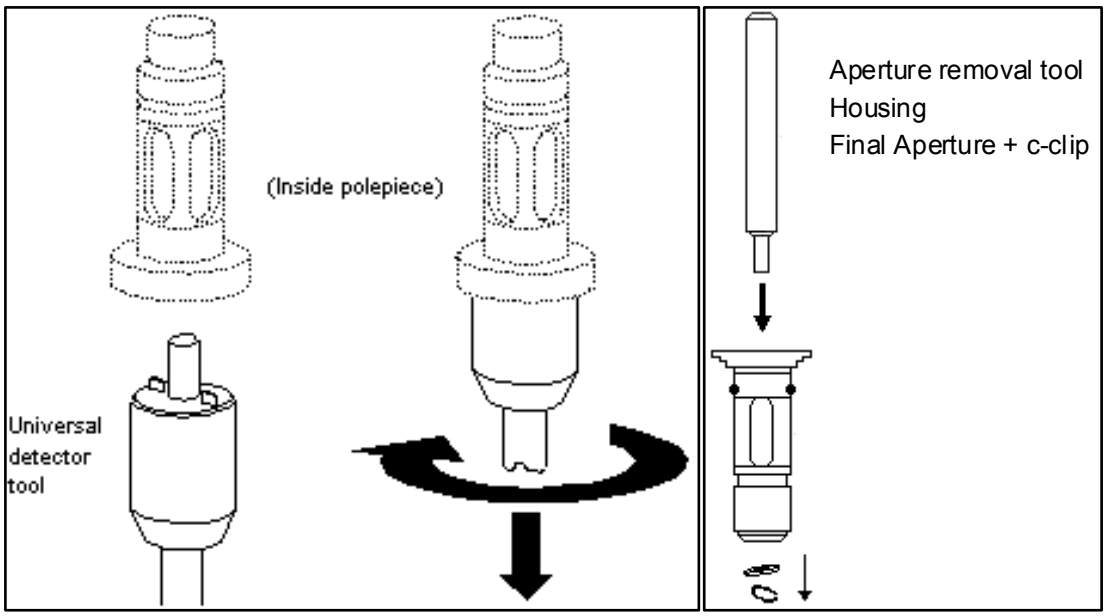
The following instructions describe how to remove and disassemble the standard insert assembly.

FIGURE 8-10 STANDARD INSERT COMPONENTS



1. Insert the universal detector tool pins into the matching slots in the insert assembly, as shown in Figure 8-11. Once the pins are engaged, twist **counter-clockwise** to unscrew the insert from the pole-piece.
2. Use the Apertures Positioning Tool to remove the C-clip and final apertures from the insert. To do this, insert the pin of the tool into the wide end of the insert and push the parts out of the narrow end of the insert. Be sure the parts have a safe, clean place to drop onto.

FIGURE 8-11 REMOVING AND DISASSEMBLING THE INSERT



3. Inspect the o-ring at the bottom of the insert. If the o-ring looks deformed or damaged, replace it. This is a critical seal between EC1 and EC2, which is in high vacuum. The surface of the o-ring must be flush against the insert.
4. Inspect the threads on the insert for dirt, scratches on the threads, etc. Clean the insert threads and if damaged, replace the insert.

8.6.2 HOUSING CLEANING

Once the entire assembly has been removed and taken apart:

1. Clean the standard insert housing with a toothbrush and Soft Scrub/CIF or alumina powder.
2. Rinse with de-ionized or distilled water.
3. Rinse in alcohol or isopropanol and dry with clean compressed air.

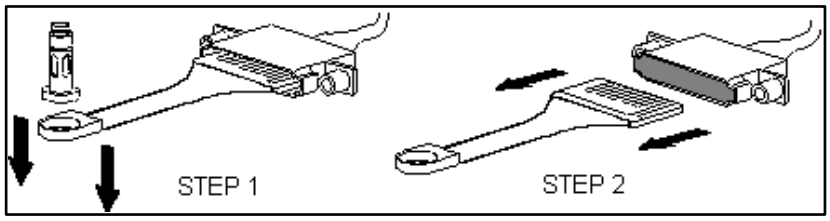
Under normal use, the insert should be inspected only when being inserted. It should only be removed for cleaning when indicated by poor astigmation.

8.7 Gaseous Detectors

8.7.1 CLEANING THE GSED OR LFD

This section will describe how to remove and disassemble the GSED assembly for cleaning.

FIGURE 8-12 REMOVING THE GSED ASSEMBLY



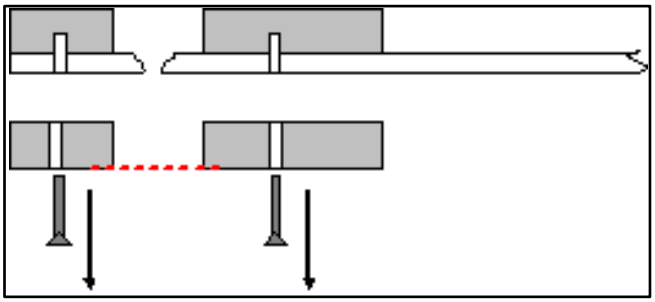
1. Vent the chamber before beginning.
2. Pull the end of the GSED detector head down to remove it from the standard insert. The insert will remain inside of the pole-piece.
3. Pull the GSED pin contact board out of the signal connector mounted to the chamber ceiling.

The PLA is part of the GSED detector and can be cleaned by inserting a toothpick (or something similar) into the hole. The signal ring is permanently attached to the underside of the detector, and can be cleaned in a similar manner.

8.7.2 CLEANING THE GBSD

1. Perform steps 1 and 2 above to remove the GBSD PC board from the chamber.
2. The GBSD is easily cleaned with a toothbrush, Soft Scrub/CIF cleaner and water, as with the GSED. To access the PLA and converter plate, remove the two screws holding the collector grid to the PC board as shown in Figure 8-11. Scrub the SE grid gently, as this can be easily damaged.

FIGURE 8-13 DISASSEMBLING THE GBSD



8.8 Stage maintenance

8.8.1 SPECIMEN HOLDERS

Recommended cleaning procedures are given below for parts which operate in vacuum and which are subject to possible contamination. Frequency of cleaning is, in most cases, determined by necessity (image quality or astigmatism level).

Cleaning

1. Clean these parts using cotton wool and a mild abrasive domestic cleaner (see list of preferred cleaners at the end of this chapter).
2. Rinse in tap water.
3. Clean in an ultrasonic cleaner for 5 minutes using distilled water.
4. Clean in an ultrasonic cleaner for 5 minutes using alcohol p/a or isopropanol.

C a u t i o n !
Do not place parts together in the beakers. Wash separately as damage can occur to the metal surfaces.

5. Rinse in alcohol p/a.
6. First blow dry with a compressed air canister, then dry thoroughly under an infra-red lamp (15 min. to 1 hr.) at a temperature of between 80° C and 100° C. Do not bake in an oven!

8.8.2 STAGE MECHANICS

Checking the condition of the stage should be a weekly exercise as many differing samples may be exchanged in this time period. Some samples may be powders or composite materials that inadvertently drop particles on or in the stage. If a silicon wafer breaks in the chamber it can shatter into hundreds of pieces. In this case the stage should be thoroughly cleaned before attempting movement again.

Cleaning Stage parts

Abrasives and solvents must not be used on the moving stage parts. Cleaning with a vacuum is the ideal method. If not available, cleaning should be done by using dry nitrogen gas bursts around the stage mechanics to blow out any foreign materials. Make sure the final lens and detectors are protected from the turbulence. Do not use sharp metal objects to scrape away debris. A fine pair of plastic tweezers can be used to pick up difficult particles. Spillages on the stage should be wiped up using a lint-free cloth, followed by vacuuming or blowing with N_2.

8.9 Refilling the Water Bottle

The water bottle in the instrument will typically need to be filled about once a month if the instrument is used on a regular basis at a high pressure. The water reservoir is located in the rear of the column console, beneath the frame. To fill the bottle, do the following:

1. Vent the system.
2. Turn off any gas connected to the gas inlet.
3. Disconnect the quick-coupler and pull out the water bottle.
4. Remove the rubber plug and refill with distilled water (not de-ionized) until 1/3 full.
5. Mount the rubber plug and install the water bottle in the reverse order of that described above.
6. Pump the system. Switch to Low Vac or ESEM mode to force automatic purging to flush any air out of the bottle and connecting tubes.

Note:
The first time the system is pumped in LowVac or ESEM mode after filling the bottle, Auto-purging may be erratic until the bottle vacuum has recovered. The removal of all the gas from the liquid must be accomplished before good imaging is possible. This is done correctly when no bubbles are produced in the water when increasing the pressure in the chamber.

8.10 Scroll Pump

Two pre-vacuum pumps are used in the vacuum system. The first one is used to pump the microscope and back-up the TMP. The second one is used to control the pressure in the specimen chamber and also helps the first pump at the start of pumping after venting the specimen chamber.

The pre-vacuum pumps are dry type pumps that do not require any user maintenance. Carefully read the pump operating manual delivered with the microscope.

It is very important that the pipes to and from the pump are not restricted in any way. If the pump exhaust pipe is fitted to an internal company exhaust system it is important that the gas flow is unrestricted by the system capability, otherwise back pressure can occur which will overheat the dry pump and deteriorate the pumping speed.